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CIVIL ENGINEERING.

On the Mechanical conditions of Railway working to prevent Destructive Wear and Risk. By W. Bridges Adams.

From the Journal of the Society of Arts, No. 623.

Continued from page 164.

Having obtained successful results in the elastic action both of wheels and rails, the next question was to obtain a true mechanical action in the movement of wheels and axles. As far back as the year 1837 the writer had sought to impress upon railway authorities the importance of radial movement in the axles, enabling them to run at a right angle with the rails, whether on straight lines or curves, and proposed various modes of accomplishing it, but he could get no attention. The railways were made in what were called straight lines, though practically crooked lines, and it was taken for granted that the coning of the wheel tires accomplished all that was wished. But in America crooked lines obtained with very sharp curves, in order to go around street corners instead of outside the towns, and a bell was suspended at the entrance, to be struck by the engine, and a notice painted on a maple slab, "Look out for the locomotive, when the bell rings." To facilitate the movement of the engine round the curves, the front end was provided with a swiveling truck, called a bogy, analogous to the ordinary under-carriage of a road vehicle, moving on a centre pin, but with four wheels instead of two, the wheels being guided by their flanges against the rails instead of by a

pole. This was so convenient, that it came into general use in America, and it was first introduced into England on the Birmingham and Gloucester line, the engines being made in America. But it was defective in principle. In ordinary under-carriages on the road, the length of the pole steadies the wheels. In the four-wheel bogy, the distance between the front and back wheels was less than the width between the rails, and, consequently, swiveling on the centre pin, the bogy was apt to run unsteadily, and drag the wheel flanges against the rails, the contact with the outer rail on curves setting the axles askew to the rails. This evil was continued on the South Devon line, where, the sharp curves necessitating the use of the bogy, it was applied on a seven feet gauge with the wheel centres five feet apart. In addition to this defect, apparently resorted to, to compensate in some measure for the fixed parallelism of the axles, it did not in any way help the skew position of the driving wheels, as the central pivot did not permit lateral movement of the bogy. To remedy this Mr. Bissell, in America, devised a plan of removing the centre pivot from midway between the four wheels to a point between the driver and the bogy; thus the movement of the wheels became radial, or in the circumference of a circle, instead of the centre. This was a plan on which the writer had built road carriages long previously, under the name of Equirotal carriages, and had proposed to apply the principle to engines. Mr. Bissell subsequently applied the same principle to engines with two wheel bogies, and time and circumstances having forced on the attention of English engineers the necessity for radial movement, other attempts were made to correct the defects of the bogy, and one was by providing a lateral slide as well as pivot movement to the centre. But on this plan the guidance was lost, and it was not found to answer.

Seeing that the time was approaching for more perfect machinery and for radiating axles, the writer again set to work to simplify the structure. Abandoning the truck form, or bogy, altogether, the axle boxes were adapted to slide in curved lines laterally through the horn plates of a rigid engine frame beneath the spring bearings. The advantages gained by this were, first, true radiation of the axle to every curve, from the straight line down to one chain an-a-half radius; secondly, perfect guidance and prevention of irregular movement in the wheels; thirdly, facility in axle bearings and lubrications; fourthly, the use of larger wheels than could be obtained by the bogy system.

The writer proposed to build the engine with coupled driving wheels in the centre, and with radial wheels at the ends, eight wheels in all, and so, having ample support, to dispense with a separate tender. This was so novel a plan, departing from the customary bogy system, that it was not listened to, and bogies were continued.

The writer sent a drawing to Mr. Cross, the engineer of the St. Helen's, and about nine months after received a letter from that gentleman stating that after having found it necessary to use larger engines for his increasing traffic, he had studied the whole question carefully as to the best principle of radiation for his sharp curves;

and having come to the conclusion that the plan of the writer was the simplest, safest, and most effective, as well as the least costly, he had constructed a model and verified it experimentally, after which he put in hand a full sized engine. (A large sized model frame of this may be seen on the table.)

After working for some time on the St. Helen's, both for passengers, goods, and coal, and perfectly establishing the soundness of the principle, this engine, called the "White Raven," was brought to London for experiment, and examined and experimented on by a large number of railway engineers, whose judgment confirmed the truth of the principle of structure.

It was at first supposed that the free movement of the wheels would tend to make the engine unsteady on straight lines at high speeds, inasmuch as front wheels, fixed laterally in the horn plates were supposed to exercise a steadying and governing power. But the contrary proved to be the fact. Another engine, altered from the rigid system to the radial, was found to run much steadier after the alteration, after acquiring the facility for rounding sharp curves. In truth the unsteadiness of all engines, apart from bad construction, arises from the fact that the wheels, fixed to the frame and seeking the path of least friction over uneven rails, force the frames to partake of their irregular movement; and, as might be expected, the inertia of the engine frame keeps it steady enough when the wheels are left free to pursue their own courses unshackled.

This novel arrangement comes at a convenient time, as the extension of railways through towns and mountainous countries is now the prevalent thought. But even for what are called straight lines, their extension into and through towns, and new station accommodation, renders it very important to have engines working round very sharp curves, and either end foremost. The great cost of land and the removal of buildings in approaches where only straight lines of very large curves can be used adds very materially to the cost of construction. But there is another question, quite as important. It is well known that the rapid wear of the rails of railways is very largely owing to the weight of the engines, apart from the train, and in the engines the destruction by rail crushing is increased in proportion to the weight on the driving wheels. Some engines have only one pair of driving wheels, as they involve less impedimental friction at high speeds. Some have two pairs coupled together, and some three pairs. Inasmuch as the engine draws the load by reason of its own weight on the wheels giving adhesion, it follows of course that a heavy train needs more weight on the driving wheels than a light one. When a single pair of drivers are used the load sometimes approaches to fourteen or fifteen tons, and this crushes both rails and tires. If, however, the load can be distributed over more wheels, this destruction may be avoided. Twenty tons on four wheels is much less damaging than fourteen tons on two wheels. For this reason our continental neighbors have been aiming at two things combined—to obtain the adhesion of many wheels with the facility of passing round sharp curves.

The ordinary method of coupling wheels by side rods does not admit of this, and the writer has resorted to another method, illustrated by the model on the table, which, as regards its eight lower wheels, is precisely similar to the St. Helen's engine, the "White Raven." But in addition to this, it has four other wheels, two of which are placed at each end resting between the central driving wheel and the end radial wheel on their peripheries, pressing downwards with any amount of weight needed to induce adhesion. In fact the whole weight of the engine and frame may be supported by the upper wheels if needed. But practically a comparatively small weight is needed, as the wheels do not merely rest on one another, as is the case with the wheels on rails, but have also a wedging action, which may, if permitted, produce an intense pressure. All the wheels have also spring tires, which ensures elastic contact and fit, without blows. It will be seen that when the driving wheels are put in motion, they communicate that motion by friction to the upper wheels, which in turn communicate the motion to the radial wheels, and continue to do so when the radial wheels are on curves, the effect being that the axles of the upper wheels depart from the horizontal line, dipping to right or left according to the lengthening or shortening of the distance between the lower wheels on curves. And the adhesion is perfect, because the load on the upper wheels forces down the lower wheels to a perfect pressure on the rails at either end of the engine. Thus there are eight drivers which may be equally loaded and the whole weight of the engine is available for adhesion. And in reversing, for the purpose of retardation, the whole of the wheels are available. To make the machine complete, brakes are applied between the driving wheels, arranged to act both against the wheels and rails by small steam cylinders, so that the retardation of the engine is within the control of the driver by simply turning his regulator and steam cocks, without needing the muscular force of his fireman, laboring at a screw with slow movement. It will be seen that this engine will run on S curves as easily as on regular curves.

Of course the steam power of an engine should be in proportion to the adhesion. Practically it is far in excess of the adhesion, inasmuch as sand is commonly used to prevent the slip of the wheels; and this though useful to the engine, is a serious disadvantage in increasing the resistance of the train. This seems certainly the case on the Great Northern, where it is found advantageous to make the tender wheels drivers, as well as those of the engine, with the same boiler power.

In the early days of railways the difficulty of adhesion between a smooth tire and smooth rails was considered to be great, before it was tried. But in those days the trains were light, and the increase in weight has again drawn attention to the desirability of increasing the adhesion. Racks on the rails and wheels might no doubt be used, as they have been, and as they are still in some collieries; but this can only be for very slow movement. Yet there is a mode of increasing adhesion not yet resorted to, but which will probably be resorted to, where the whole difficulty of mounting steep ascents, such as one in

twelve, or 440 feet to the mile, shall occur on any sharp curves. It is to convert the rounded flanges of the wheel tires into two flats at an angle of 45 degrees, and enlarging them to take a corresponding groove formed in the surface of the rail. The driving wheels of the engine only are to be fitted to these grooves, and the ordinary flanges of the train wheels can easily pass, being of smaller size. It may be remarked, that it would not be easy to lay rails accurately enough for this, and especially on curves, but compensation can be easily provided by the use of spring tires sliding laterally on the wheels, and there is no reason why the eight coupled engine before described should not work perfectly well in this mode, on sharp curves and stiff gradients. The pair of wheels on the table illustrate this principle of spring tires with angle flanges working in V grooves. The diagram on the wall illustrates this.

Thus with radial axle, spring tires, angle flanges, and elastic permanent way, several difficulties are got over. The blow and sledge movement is removed from between wheel and rail, as well as the grinding action against the flanges, and the adhesion is ensured, while the permanent way is rendered really permanent.

It may be objected to that the angular flanges will tend to wear away both tires and rails. This is quite true, but if we want to do hard work we must pay for it in some shape or other. The only question is, is it worth doing, and if so, what is the least costly method as well as the most effective and simple. We know that we can drive machinery by friction pulleys, and there is no mechanical reason why we should not drive railway trains. And these tires can be removed and replaced with perfect facility without needing workshops.

But it is not merely the question of engines that we have to deal with. It is that of carriages and wagons also. These vehicles have been kept short, and their wheels disadvantageously near together, chiefly on account of the difficulty of curves. This system needs remodeling, but there are so many considerations that it must be deferred to another paper.

Discussion.—Mr. Rochussen fully agreed with the principle laid down, that in order to neutralize as much as possible the wear and tear of materials by friction, they should have elasticity, and that elasticity might easily be promoted by the improvement of materials themselves as pointed out in the paper. There was no doubt the introduction of steel into the manufacture of rails tended to add to the durability of the rails as well as to introduce the element of elasticity to a large extent. The Bessemer process enabled them to produce steel rails at a comparatively low cost; at the same time it had not superseded the other description of steel rail which was largely used on the Continent, viz: the puddled steel rail, by which the tendency to split, spoken of in the paper as occurring in the common iron rail, was obviated and the advantage of puddled steel was, that it welded well with iron. Thus they had a flat-bottomed or Vignolles rail, which was still used to a large extent on the Continent, consisting of a head and web of puddled steel, and an iron base. The welding of the steel and iron

was complete, and while this combination gave a harder surface to the tread of the metal, the elasticity of the iron was retained. He had seen the advantages of that combination of material at the Hamm station of the Cologne-Minden railway, the traffic of which was equal to that of Cresse, where steel headed rails with iron web and base had been in use for ten years and showed no signs of wear. Bessemer steel would not weld well with iron, and therefore it was best adapted for the double-headed rail. As far as the elasticity of rolling stock was concerned, he greatly admired the plan of Mr. Adams, of introducing an elastic material into the tire of the wheel. But he (Mr. Rochussen) would remark, that the combined steel and iron he had spoken of in rails, was also applied to wheels, and offered all the advantages of elasticity contended for. Both wrought and cast iron disks in straight section were objectionable, whilst in a corrugated section the wheels have a power of contraction which counteracted the force of the blows; and, on the other hand, they had but little vibration laterally. The great advantage of the disk wheel was that it did not raise the dust as the spoke wheel did, and obviated the great atmospheric resistance which the fan-like motion of the spokes created. With regard to the system advocated by Mr. Adams, he would ask how it could be ascertained when the piece of *lignum vitæ* or other wood inserted between the wheel and the tire showed signs of decay, as it was completely hidden from view, and there were no visible means of knowing when it became in an unsound state. While on the subject of disk wheels, he would remark that wrought iron disk wheels, which were much in use on the Continent, were working their way gradually in this country. In the Exhibition of 1862 a manufacturer with whom he was connected, showed some driving wheels on the disk system, which weighed 2½ tons each, made of cast steel, that material being considered better than wrought iron; but it appeared that wheels of that description were greatly affected by severe changes of the temperature of the atmosphere, and in one night no fewer than nineteen of those wheels cracked, while there was no instance of wrought iron disk wheels having given way under atmospheric influences. The iron was forged from the bloom, with a hammer weighing five tons, and the cast steel tire was batted on to the T-piece of the disk, or a puddled steel tire was used and welded to the disk, and as the steel surface of the tire wore off, it could simply be turned down, and another steel tire slipped over it, but hitherto no instance of the wearing out of such a wheel had occurred. The axles are not keyed in, but pressed into the wrought iron nave with hydraulic power.

Mr. Dennet felt much indebted to Mr. Adams for the paper he had read, but he wished that gentleman had gone a step further, and had given them a little more information as to the means of avoiding many of the risks of railway traveling. With regard to wear and tear of the line and plant, it was a question of great importance, in which the shareholders of railways were very much interested. There was an invention connected with this part of the subject to which he would call attention. The inventor of it, Mr. Jowett, he had hoped would

have been there that evening to explain it, but his sudden and unexpected death within the last four days had deprived them of the valuable information which he would have furnished. The invention alluded to was a form of fish-joint, models of which were on the table for the inspection of the meeting. For this invention he had received but £12 10s., whilst it had been disposed of to a company for £21,000 and they had realized from it £80,000. Mr. Dennet then called attention to the specimen of rails, sleepers, plates, and a new fish-joint, all of which were the invention of Mr. Jowett, and he pointed out the advantages of this "rail" and mode of setting as obviating two or three difficulties in railway traveling. The ordinary rail was from five to seven inches in height, and being fixed in iron chairs on the top of the sleepers, there was a vibratory motion, which gave that zig-zag movement so unpleasantly experienced by railway travelers. In the model before the meeting the rail was set in a groove to half its depth of the sleeper; there was a slot or hole cut in the rail, through which a wrought iron wedge or plate was inserted eight or nine inches in length by four or five inches in width and one inch thick, which plate was fastened to the sleepers by bolts or spikes. By this plan there was not only a saving of wear and tear of the rail but an economy in first cost. It could be adapted to rails of any material and of any shape. It could be applied to a light but serviceable rail, it dispensed with the wooden keys and chairs and lessened the number of sleepers by two in the length of rail. The saving in the cost of laying rails was equal to £300 per mile. In India it would be found that the economy of this plan was equal to £400 per mile, or £40,000 in 100 miles, while in this country the saving would be about £28,000 in the same length of line. Mr. Dennet added that this plan had been tested during seven months on a short length of the South-Western Railway, where it could be seen by those interested in the subject.—Mr. Dennet also exhibited a form of fish-joint which he considered novel, and highly advantageous and practical.

Mr. Zerah Colburn, on being appealed to by the Chairman, said his observations had been confined mostly to lines in America, and, as far as his experience went, it bore out the soundness of the principles brought forward by Mr. Adams. The American lines were, for the most part, imperfectly constructed, partly from the inferior quality of the earthwork and want of ballast, and to a great extent from the bad form of rail—the common contractors rail, with a flat foot, but of bad shape and bad quality of iron. Mr. Colburn explained the form of rail generally used, showing how the contractors form of rail, which could readily be fished, had, owing to the bad quality of the iron, in order to gain strength been altered into a form which did not admit of fishing. Nevertheless it was the fact that American carriages traveled over these lines as smartly as first class carriages on the superior lines of this country. This he thought was mainly due to the use of the bogy, the great length of the carriages, and the manner in which they are hung. The bogy had the advantage of going round curves easily, and the mode of attaching the carriages to it distributed the

weight more uniformly; if they met with an obstruction the shock was not imparted to the carriage. The arrangement for allowing the carriage to swing freely on the body of the bogy, as adopted in America, had been introduced on the Metropolitan Railway, where it would be noticed that the carriages have a peculiarly easy motion. Mr. Adams had spoken of the bogy as having been originally invented in America, but he believed it was first introduced by Mr. Chapman, of Newcastle, in the year 1812, and was first used there. It was taken up in America at an early period, and had continued in general use ever since. It was the opinion of some locomotive engineers in this country that the use of the bogy to engines and tenders was not so safe as placing the wheels in the ordinary manner. He thought that was a mistaken opinion. He had designed some rolling stock for one of the Brazilian lines, and in opposition to his advice the bogy was dispensed with; but experience in the working of heavy gradients and sharp curves led to the ultimate adoption of the bogy. With regard to elastic wheels, something on the principle described by Mr. Adams had been used with success in the States of America, but not of the form which that gentleman had described.

Mr. Dennet inquired whether Mr. Colburn could give any information as to the description of wheel in use on the Massachusetts line, which he had been informed had resulted in great economy of wear and tear.

Mr. Colburn was not acquainted with the kind of wheel used on the line mentioned. He apprehended it would be something similar to those on the South-Eastern line in this country, viz: segments of wood put together. He would, however, add that one objection to the bogy was the necessity it entailed of using wheels of small diameter. A larger diameter than three feet was never used. As a rule the carriage wheels were 2 ft. 9 ins., and the engine wheels 2 ft. 6 ins., and for goods engines only 22 inches. The plan of Mr. Adams enabled a much larger wheel to be used, and this was, in his opinion, a decided advantage.

The Chairman said there was no doubt Mr. Adams had introduced a very important subject for discussion that evening, advocating, as he did, a radical change in the construction of our railways and the rolling stock. On the first introduction of railways he had no doubt it was in the recollection of many that a very rigid road was made. In the first instance the rails were laid on chairs fixed into stone blocks, and one line, he believed in the north of England, they actually built brick walls, on which they laid the rails. All those arrangements caused the rails to be knocked to pieces very soon, and engineers then resorted to wooden sleepers laid upon ballast. The Great Western Railway was, in the first instance, constructed by Mr. Brunel by laying longitudinal sleepers on piles driven a considerable depth in the ground, but at the points where these piles supported the longitudinal bearings great injury resulted. These piles were consequently all removed. The system was changed, and the sleepers were laid simply upon the ballast. This, therefore, appeared to be the great object at which rail-

way engineers were aiming in order to avoid or mitigate the shocks produced by railway trains. He therefore thought no one would be disposed to object to a trial of the plan proposed by Mr. Adams. To him (the chairman) it seemed a most reasonable plan; but, of course, in railway experience it would not be prudent to express any very decided opinion upon a new principle of construction until it had been tried for a considerable time. The arrangement which Mr. Adams proposed for making the tires revolve on the wheels was certainly new. It had been tried, and was a great advantage. It had long been sought by railway engineers to make the wheels revolve upon the axles. The principle of Mr. Adams was very much to the same effect. It made the periphery of the wheel the point at which the revolution took place instead of on the axle. With respect to the fish-joint which Mr. Dennet had claimed for Mr. Jowett, he believed there were a great many persons who laid claim to its invention. He knew that Mr. Adams put in claims for that many years ago, and he knew many others who also laid claim to a mode of fishing rails. He had no doubt that by Mr. Jowett's plan a certain amount of elasticity would be obtained, but Mr. Dennet had not stated whether the sleepers themselves would not be weakened by that arrangement.

Mr. Dennet replied—Not at all; quite the reverse. He would add that he did not claim for Mr. Jowett the invention of the fish-joint, but that particular form of fish-joint to which he had referred. It was different from that of Mr. Adams's, the ingenuity of which he did not wish to detract from.

The Chairman said he remembered a system of fixing the rails into timber as long as twelve years ago—not exactly like that shown to-night, but very similar to it, which was tried on the South-Eastern line near London-bridge.

Mr. Dennet said that Jowett's plan of fixing the rail in the wood was different from that alluded to by the Chairman, and was quite new. In the plan referred to by the Chairman the metal was embodied in the wood.

The Chairman then proceeded to say that these various proposals of Mr. Adams undoubtedly tended to diminish a very great amount of the friction which took place in railway trains: and any diminution of those forces would practically be a diminution of the cost of working and an increase of dividends to the shareholders; and he trusted it would eventually lead to a diminution of the fares charged to the public. In that respect these matters were of the greatest public importance, and he was sure the meeting would readily accord their thanks to Mr. Adams for his very able paper.

The vote of thanks having been passed,

Mr. Adams said he took no credit to himself for the invention of the fish-joint, for five hundred different people, setting down to patch a rail as he did in the first instance, would probably have come to the same conclusion, only he happened to be the first to place such an invention on record. He never considered the fish as used was good, and he set himself to devise what he thought was a good fish on the plan

he had laid before them. With regard to wheels, he did not enter into the question of which was the best structure, but merely alluded to the disk wheel as a form to which he wished the elastic tires to be applied; but the spring tire was applicable to all kinds of wheels, whether on common roads or on rails, and the section on the wall showed a mode of applying spring tires to road locomotives. The subject was too extensive to be dealt with in one paper, and he would deal with other branches in the paper which was to follow. He wished, however, to impress upon the meeting that it was perfectly practicable to make engines to go round curves of a radius of 1½ chain, and he claimed a plan of distributing the weight upon all the wheels of an engine instead of principally upon the driving wheels. As to the mode of fixing the rails in the sleepers, there had been several plans proposed of cutting the sleepers, but they were all open to the objection that by cutting into the material of its sleeper its strength was impaired. If a sleeper with the ordinary chair required five inches in depth, then when it was cut away to the depth of three inches, it ought to be eight inches in depth in order to make up for the part cut away.

The Construction, Traction, Retardation, Safety, and Police of Railway Trains. By W. Bridges Adams.

From the Journal of the Society of Arts, No. 629.

(Continued from page 153.)

Discussion.—Mr. Dyer said they must all feel much indebted to Mr. Adams for his paper, which contained many valuable practical suggestions, but it did not embrace the popular view of the safety of railway trains by night and by day. The popular view was how the safety of passengers could best be secured, and how the casualties of railway traveling could be diminished. With this in view he would call attention to a few statistics taken from the annual reports of the Board of Trade, which showed that there was great loss of life annually throughout the kingdom from railway casualties. Those statistics had been tabulated only since the year 1861, in which year he found that there were 284 persons killed and 883 injured; in 1862 there were 216 killed and 600 injured; and in 1863 there were 184 killed and 470 injured. These figures showed a large amount of loss of life and injury to persons by railway traveling, making a total for the three years of no less than 2637. The question in which the public were interested was, could this loss of life and injury to person be reduced? and in this they were more interested than in the mechanical management or construction of a railway. A great number of lives, he believed might be saved, in cases of collision, by a contrivance (a model of which he had placed on the table,) and which, he said, would prevent the upsetting of carriages in case of collision. The loss of life occurred, in a great measure, from the upsetting of carriages on the road. If the carriages could be maintained in their proper position, the passengers would seldom suffer more than a violent shaking, but, immediately a collision occurred the upsetting of the carriages en-

sued, and loss of life and injury to person, to a great extent, was the result. He considered the present buffer arrangements of trains extremely faulty, inasmuch as their line of action was too low, and gave a leverage or pressure, which in case of collision lifted the carriage over. He held that there ought to be what he termed a square pressure from end to end of the train, which would enable the carriages to sustain the pressure without being upset; in other words, the carriage could be pressed to the extent of the crushing power before it gave way. The arrangement he suggested consisted of a top and bottom line of buffers, which rendered a train like a continuous carriage in point of resistance to pressure from end to end. If the train could be formed of one continuous carriage, upsetting would be impossible, for, however violent the concussion might be, it would be impossible to upset the carriage. The arrangement of buffers he had suggested would practically make the train into a single carriage. Another question was the frequent loss of life that occurred at station platforms, from persons getting in or out of carriages while in motion. He submitted that all the platforms should be built up to the level of the flooring of the carriages, and that a dangerous space between the platform and the carriages ought not to exist. There was a great want of uniformity in the height of railway platforms. He found at Charing-cross station the height of the platform was three feet, while the average height of the flooring of the carriages was about four feet from the rails; consequently, there was an ascent of twelve inches to the carriage. At London-bridge station it was about the same. On the Brighton line, at London-bridge, the platform was only twenty-four inches in height, which gave an ascent of two feet to the carriages, with a space of eighteen inches between the edge of the platform and the carriages, and this he held was dangerous in the extreme. However thoughtless or stupid the public might be, they found that casualties from falling between the edge of the platform and the carriages frequently occurred to the servants of the companies, who might be supposed to know the danger that existed. Mr. Dyer instanced the casualties that had lately occurred from this cause at the Erith Station, when the platforms were crowded with persons returning from the scene of the recent explosion there. He also quoted from the Board of Trade returns other accidents which he said were merely recorded as "passenger killed from want of caution," &c. He thought the Government ought to instruct the inspectors to inquire into and report the conditions and particulars under which the occurrence took place, but this was not done, except in the more serious cases of accidents. He thought many of the present dangerous arrangements on railways ought not to be allowed to exist, and that it was the duty of the Government, upon the neglect of the Companies themselves to do so, to enforce the necessary precautions to ensure the public safety.

Captain Humby could not see the practicability of the arrangement of buffers that had been suggested, to carry out which would involve the necessity of building excessively heavy carriages, whereas it was considered essential, both in regard to speed and comfort in traveling

to build them as light as possible. He thought if such a system had come under the notice of Mr. Adams in a way that he could entertain he would have noticed it in his paper, and given his opinion upon it.

Mr. S. Teulon said the last speaker but one had suggested that railway carriages should be provided with two sets of buffers. He would appeal to gentlemen who had any knowledge of mechanics and of the laws of bodies in motion, whether it was not undisputed that the best point at which to stop a body in motion was not as near as possible to its centre of gravity. In the case of an engine with the boiler filled with water, and perhaps carrying a tank on the same frame, he submitted that the line of the centre of gravity was not very far from where the buffers were ordinarily placed. At one time the practice obtained of stopping trains on sidings by the very ready but, as it proved to be, very dangerous method of turning up the ends of the rails. The consequence of this arrangement was, that as the centre of gravity was above the wheels, they, coming in contact with the bent up iron, had a tendency to be thrown out of their places. The remedy for this was found in putting up an earth bank, against which the buffers impinged, and he could state, from his experience on a very large railway, that since that plan had been adopted the injury to the wheels and axles had been largely diminished. In the plan now suggested what would be the consequence of any thing happening to the lower buffers? If the top buffers took the strain, it would push the roof off the carriage, which, he apprehended, would be very inconvenient to the passengers inside it. With regard to the complaint that the platforms were not placed at a uniform convenient height, it must be remembered that railways were not the system of a day. They had gradually grown up, and improvements had succeeded from time to time. In making a new station, such as the Charing-cross, the directors had adopted a higher platform. The Brighton station was built many years ago, but he had no doubt, when it became necessary to make new stations, the directors of that company would follow the example of their neighbors, the South-Eastern. While speaking of the Brighton Railway, he would notice a passage in Mr. Adams's paper, in which he referred to a subject which had excited a great deal of public discussion, viz: the alleged injury to the health of persons constantly traveling by railway. The best answer to that allegation was the fact that, taking the statistics of the Brighton Railway he found a very large increase from year to year of the class of passengers daily traveling to and from Brighton and intermediate stations as season-ticket holders. The report which was distributed among the shareholders of the South-Eastern Railway Company it the early part of this year contained a table, which showed that while in 1855 the season-tickets brought in near £21,000, the amount had gone on increasing year by year, with but one exception, until up to the present year it reached the sum of £34,693. He at one time, as a traveler by railway and road 72 miles, four or five days in a week, fell into the notion that he was being seriously injured by his railway traveling; but he must own now, having continued that injurious practice for upwards of ten years, he had the satisfaction of enjoying much better health than

ten years ago. It was fair he should state the result of his own experience. He attributed much of the injury which some passengers suffered to this cause, viz: the short time that persons gave themselves to reach the station, which led to their arriving and entering the carriages in a flurried and heated state, unfit for traveling, especially in cold weather. They sat in drafts caused by the carriage moving rapidly through the air, and the caloric of the body was rapidly drawn from the feet, and the proper circulation of the blood interrupted. He turned from this question to the practical matters treated of in the paper. With many of the points advocated by Mr. Adams he entirely agreed. He agreed that a great deal of the mitigated wear and tear of railways and rolling stock was to be attributed to the better form of construction both of the line and the working plant. He had taken a little trouble in this matter since the last meeting, because he held it was of great advantage to discuss these subjects with a number of gentlemen more or less conversant with it, and although they might not agree on all the opinions expressed, they were in all cases the better for exchanging ideas with each other. In the year ending 1855, on a railway on which 2272 carriages were employed, it was necessary to "turn up" from wear 1884 pairs of wheels. The actual result was ·6726 as the proportion of wheels turned up in 1855, whereas for the year ending July last, the number of vehicles having been materially increased, and increased in size as well, the capacity of the wagons being increased from four and five tons to eight tons, they still found this gratifying fact, that the ·6796 in 1855 was reduced in 1864 to ·6533; and it was an equally gratifying fact that the quality of the tires—a matter on which Mr. Adams properly laid great stress—had very much improved, especially the Staffordshire tires. He found, on a comparison between the wheels used on two of the large metropolitan lines, that while in the four years ending 1863, when a great many Low Moor tires were used on the one line, the result was a loss of ·60945, on a neighboring line with Staffordshire tires it was ·60990, being a mere difference of $\frac{4}{10000}$, and showed very favorably for the Staffordshire iron, which, ten years ago, they hardly dare use, as the quality did not near come up to that of Low Moor. With regard to wheels, the railway he was connected with (South-Eastern), gradually, during the last fourteen years, ceased to have perfectly solid iron wheels; they employed wood placed endways above a plate inserted for the centre of the wheel, and built up to form a wooden disk on which the tire was put by hydraulic pressure; they had also done this, and done it very successfully, viz: placed a rim of wood between the iron wheel and the tire. He should state that the former plan was patented by Mr. Mansell, the carriage superintendent of the South-Eastern. As the tires had become worn, they had cut out of hard wood a segment of an inch or an inch and a half, and placed them between the inside of the tire and the iron forming the old wheel. These plans had answered so well, that whilst during the last severe winter, the tires of 150 pairs of wheels, some on iron, had elongated, where this hard wood had been placed between the tire and the wood

of the disk, there was no wheel amiss, a very important matter in times of severe weather. The elongation of tires in winter time had been a very vexed question, but he thought a little consideration would bring them to this conclusion. The road in severe weather, especially if the frost had been preceded by wet, was in its most rigid state. Then the inner portion of the wheel, when of iron, was in effect the same as if the tire was placed between rollers, and consequently it elongated the tire. With reference to the model of an elastic road shown by Mr. Adams, he imagined that was another move in the right direction, and that plan had been adopted on one of the lines running from Manchester. The chairs were placed between the wheels, as in that model, and he stated this on the authority of Mr. Ashcroft.

Mr. Adams—If the plan was good why did not Mr. Ashcroft employ it on his own lines?

Mr. Teulon said it must be well known to Mr. Adams that a framed longitudinal road was formerly employed on the viaduct portion of the Brighton line, and was one of the best parts of the line; but owing to the great number of trains, when it was taken up it was impossible to put down another road like it. It was, however, in use some ten or twelve years with success. With regard to the spring tire wheels which Mr. Adams had shown, he (Mr. Teulon) thought that in ascending inclines difficulty would be found, inasmuch as the wheels would slip in the tire for want of sufficient friction.

Mr. Adams—The objection could only apply to the driving wheels of engines; as regarded other wheels, facility of slip was a positive advantage. As regarded driving wheels positive experiment, which was worth more than any theory, had demonstrated that even when the tires, as stated in the paper, were so loose that they could be moved round by hand (with the weight lifted), they drew their load perfectly well. Mr. Adams would go further, and say that loose tires, even without springs, would act in the same way, although of course disadvantageously for want of the elastic interception of blows, and the equalizing movement of the tire on its basis of contact with the rail.

Mr. Teulon added that Mr. Adams had stated very correctly that all changes with regard to railway plant, especially with heavy and powerful bodies like engines, must be made with great caution, and therefore he was content to wait on this point till he saw more of the results. In conclusion he would say a word on the subject of the fish joint. He saw by Mr. Adams's previous paper that he did not call in question the fish-joint at present in use, but he said he had got something better. He (Mr. Teulon) thought the public was very much indebted to Mr. Adams for his original fish-joint, and he hoped that gentleman had reaped some of the benefits of that invention. [Mr. Adams—Not a sixpence.] It was a good joint if the fish were properly made, and was one of the best things that had been introduced on railways for a long time. He would not say Mr. Adams might not have improved upon it, but the original joint had been a great advantage to all railways that used it.

Mr. Adams, in reply to the observations that had been made, said

the model of the suggested application of double sets of buffers was simply a supplementary mode of attaining what he himself had advocated in the paper, viz : the long carriage. In the early days of railways a single buffer was used in the centre, but it was abandoned for the two side buffers. He did not agree with Mr. Teulon that it was a bad plan to put buffers in the position in which they were shown in the model, because it was notorious that short carriages would ride upon one another's backs. No sooner did they come into collision than, with four tons of buffer springs pressing, the first thing they did was to mount upwards on each other's backs, as they could not move downwards or sideways. That was well known from experience. He did not think that two sets of buffer springs, one above and one below, were desirable, but he thought it would be an advantage to apply cushioned blocks to the upper corners of the body, flush with the buffer heads when drawn home, to lessen the risk of the tilting upwards. With regard to the question of health, he could not fight against statistics ; but in his paper he had alluded to what he understood was the fact, not that season tickets originally taken by gentlemen wishing to travel morning and evening to and from Brighton had been discontinued, but that very few persons could keep up the daily practice ; and though the season tickets might have increased in amount *non constat* that all their owners traveled with them morning and night.

Mr. Teulon said his inquiry had been especially directed to that point, and there were persons traveling backwards and forwards continuously.

Mr. Adams was glad to find they had such quality of muscle in England, but one engineer had told him the practice did not suit him. And it was notorious that the faculty discouraged their delicate patients from the use of the railway. With regard to the wheels which Mr. Teulon had alluded to, before that gentleman had gone far in his remarks on that subject, he (Mr. Adams) was prepared with a reason why the wheels on the South-Eastern Railways had lasted longer. It was solely due to the fact that they were wheels with solid wooden disks, which to a certain extent rendered the wheels true circles, and also removed the inner anvil from the tires. They could not hammer the tire on the surface of the wood as they could on an iron surface, just as the shoemaker in hammering his sole leather could not do it on his thigh as he could on a solid lapstone. As to wooden wheels, nobody knew more about them than he did. He was at one time a manufacturer of carriages and engines, and had turned out a great many of them. There came to him an order from the South-Eastern Company for a number of very long carriages. Those carriages were notoriously the steadiest carriages that ever ran, but they did not answer in one respect, as he had not in them a radial movement of the axles, and the flanges cut against the rails. When the order for them was given, it was specified that the wheels were to be constructed on Mr. Mansell's patent. That patent was not for wood wheels, but consisted in applying, in an ingeneous manner, a pair of angle iron

rings which keyed laterally into the grooves of the tire, and held to the wheel by cross-bolts through the wood, piercing through the head of the tire. In making a wheel the worst thing they could do was to make a hole through the tire, because it deprived it of a portion of its strength—probably one-third. Another thing was, when the tire got loose on the wheel it indicated danger, which arose in this way—Where the tire was stretched by the process of rolling over the rails, the wheel being held down in eight points, it could not stretch where it was held, but became polygonal in stretching out between them, and the wheel in other parts became a sledge hammer, and in frosty weather, the rivets got broken out. The original wheels of Mr. Mansell were composed not of a disk of wood, but of a series of screw spokes, the outside secured in the felly, and the inside in the nave of the wheel. On looking at that plan, he declined to make such wheels. He was asked how he could do it. He replied, make them solid disks with a series of radial timbers. He was told that was the patent of another superintendent, but he doubted the fact, as it had been done by Mr. Dricks many years before. He (Mr. Adams) had machinery made to cut the timber for those wheels, and they were the first that were thus made for the South-Eastern line. He was then putting on Park-gate tires, said to be of brittle iron, but he found it perfectly hard, and of good quality. While these wheels were in course of of manufacture, an accident occurred on the Midland Railway by the breaking of a tire, which cut through the bottom of the carriage, and nearly killed the railway king, Mr. Hudson. Inquiry was immediately made of the officials whose tire was that had broken? and on being informed it was Park-gate, he issued orders that no more of those tires should be used on any railway of which he had the command. Upon this he (Mr. Adams) was asked if he intended continuing to use the Park-gate tires? He replied he did. He was told they would break, to which he replied he was putting them on the wooden disks by pressure, and by no subsequent pressure could there be sufficient tension put upon them to break them. He believed these wheels had never broken a tire. The greater duration of the South-Eastern wheels was, therefore, due to the action of the wood, which prevented the rails and chairs becoming anvils for the tires to act upon. In America Mr. Griggs had put his engine-tires on with wood between the tire and the wheel, and by that means, no doubt, had increased the duration of the tire very considerably; but in the case of a wooden wheel, if the tire got loose by any chance and began to move round, it would soon grind the wood wheel away. With regard to his plan of laying the rails elastically, a few years ago, Mr. Chubb, a director of the North-London Railway, complained to him of the destruction of the rails on that line. His reply to that gentleman was, that they did not lay them right, and he offered to give him a plan if he liked to use it. A few lengths were laid down on the North-London line with the ordinary rails and in other places. The rails did not touch the longitudinal timbers, and were supported, not by chairs, but by brackets. They had been down three years, but they exhibited no signs

of destruction on the top, as was the ordinary result of the anvil action of the chairs and hard ballast. At the time he read a paper on this subject before the Institution of Civil Engineers, it was stated that that kind of road had been adopted before, but he was unable to find any trace of it, in any book or publication, or transactions. It was asserted that it had been done by Mr. Buck, who he admitted was a perfect judge of a good line. He inquired where it had been laid, and was informed on a viaduct; but it had not been renewed on the same plan, and no one knew anything about it except those who laid it down. Mr. Teulon said he got his information from Mr. Ashcroft. Now the latter gentleman was a member of the Permanent Way Company, which had become possessed of his (Mr. Adams's) fish-joint. It was a company got together to secure all that was good in patents of every kind appertaining to the permanent way of railways. Mr. Ashcroft was, he believed, still a member of that company, and had a patent for a permanent way of his own, on which many heavy chairs were used, and it was only natural he should give the preference to his own plan. But that fact precluded either him or Mr. Teulon, who acted under his advice, from being unprejudiced judges of any clashing plan. He gathered from Mr. Teulon's remarks, that he wished, under his information from Mr. Ashcroft, to make it appear that he (Mr. Adams) was not original in his elactic system. But the truth he believed was, that Mr. Buck, a man in his own right, and not a copier, did use on a viaduct a system of interspacing his chairs between the rigid supports of the frames, to save the viaduct from damage. But in what was called the permanent way of railways, no such system was ever used. He (Mr. Adams) had embodied a known principle of nature to counteract the evil of hard ballast, more than once alluded to by the late Robert Stephenson, in discourses at the Institution of Civil Engineers. Mr. Buck was a man of clear perception, and he also took patents, but never took a patent for this elastic system, or ever mentioned it before scientific bodies. With regard to the framed longitudinal road on the Brighton line, alluded to by Mr. Teulon, it was laid with continuous bearing bridge rails on longitudinal timbers. The bridge rails deflected under the wheel and sunk into the timber to an inch or more in depth. An engineer of the South-Eastern line, when he first saw a rail removed asked, very innocently, "Why do you groove your rails into the sleepers?" thinking it had been done from the outset. This line was always harsh and rigid, and not one to be recommended. He (Mr. Adams) had devised a general system, and applied it equally to timber and metal sleepers, to prevent blows and breakage. With regard to the fish-joint, when the original joint was produced, he (Mr. Adams) had not intended it to be used in the way it was now used. It was produced as a parallel support to the rail ends between two chairs, six inches apart; afterwards, for the sake of cheapness, it was proposed to bolt it. The form which was good in the chairs as a parallel fish was not proper as now used. It was notorious that the fishes bent at the joint, and as they had only three inches depth between the two upper tables of the rails, they were not deep enough to supply an equivalent in strength

to the depth of the rails. Another thing was, they were parallel, and, being parallel, they added more strength than was wanted at the end of the fish to the rail, and that caused a blow, and less strength than was wanted at the joint of the rail, and that caused another blow. He (Mr. Adams) had now devised another form of fish. It so happened that the Permanent Way Company had made what they called, an improvement in fishes, and probably a dozen patents for improved fishes had since been obtained, and it was certainly competent for him, who originated the fish, to make improvements upon it. He did not think the public were thereby endamaged, nor did he think either the public or Mr. Teulon would desire to dispute his right to make a profit of his further improvements, even though the first fish had yielded a miraculous draft of coin to its possessors. He had seen few fishes of a worse form than the last pattern on the South-Eastern line.

Mr. Davis wished to state that he had had some experience of the engine alluded to in the paper, as having been constructed for the St. Helen's Railway, and was present, in company with the most eminent engineers and locomotive manufacturers, at the trials made with it on the North-London line. When running on a straight line, at a speed of 68 or 70 miles an hour, he was very much struck with the beautiful motion of the axle boxes. Running at that high speed, an inequality of the rails would sometimes cause the engine to give a jump on one side, but it immediately righted itself in the most beautiful manner. After the experiments he examined the wheels, and he noticed that the flanges were not abraded, but the tire had formed a groove corresponding with the surface of the rail. Although the papers of Mr. Adams were very comprehensive, there was one subject which had not been touched on. It had been stated in the discussion that where one carriage ran off the line, if the couplings did not break, the other part of the train would be dragged to destruction. He had brought under his notice a very clever invention, by which the couplings of the carriages were so arranged that, taking into account the sharpest curves, the couplings, by a clever mechanical arrangement, immediately disconnected the carriage from the other part of the train, and saved it from destruction. He thought this contrivance should be more prominently brought before the notice of railway managers than it had yet been.

Mr. Adams said that on the St. Helen's engine they were all spring tires.

Mr. Davis replied in the affirmative, and added that he was much delighted with the sensible improvement in the non-vibration of the engine.

The Chairman had great pleasure in proposing a vote of thanks to Mr. Adams for his excellent paper. It was only to be expected that, looking at the scope of subjects embraced in this and the previous paper, difference of opinion on some points would arise. An objection had been taken this evening that Mr. Adams had not cared sufficiently for the public safety in railway traveling. Now if he understood aright the suggestions of Mr. Adams, they went very much in that direction, not only by diminishing the wear and tear of railways, but

they had much to do with regard to the safety of the trains. He would not detain the meeting by entering into the fish controversy, but it illustrated the old adage that "there are as good fish in the sea as had come out of it." The first fish, and a good one, had been produced by Mr. Adams, and he was now ready to produce a better. Mention had been made of the safety of railway carriages, arising from their length and breadth, but no mention had been made of carriages having upper stories. For several years past that description of carriage had been worked on the Bombay and Baroda line, with much success and much safety, and so agreeable had it been found by the passengers, particularly the natives of India, that the company with which he was connected (Scinde, Punjaub, and Delhi,) had adopted the plan, and used it for a considerable period. He would state as a question of railway management, that they could convey in one of those carriages very nearly as many as they could in three ordinary carriages. Hitherto no accident had occurred, and the natives infinitely preferred the upper story. As one for many years connected with railways, he would express how gratifying it had been to him to have been present on this occasion, for he felt he had received a great deal of instruction, and it was very agreeable to him to hear that as they gained experience in railway construction the dangers of that mode of traveling were materially diminished.

The vote of thanks having been passed,

Mr. Adams acknowledged the compliment paid to him, and remarked that one element of safety in reference to those carriages on the Indian lines consisted in the gauge of 5 feet 6 inches, which allowed a wider base for the wheels of the carriages. With that gauge they could do a great deal more than with the national gauge of this country.

Proposed Great Iron Girder Bridge.

From the London Builder, No. 1140.

A great railway undertaking, resembling in character the Britannia, Saltash, and Victoria bridges, and surpassing even these in point of dimensions, is to be submitted for the sanction of Parliament in the ensuing Session. The North British, and Edinburgh, and Glasgow Railway Companies have given notice of a Bill empowering them to construct a great iron girder bridge across the Firth of Forth from near Blackness Castle, three miles above Queensferry, on the West Lothian coast, to Charleston, in Fifeshire. The plans of the bridge have been prepared by Mr. Thomas Bouch, C. E. The length of the proposed bridge is 3887 yards, or two miles 367 yards. It will be about 17 miles from Edinburgh, and 34 from Glasgow, and is intended to accommodate an express route from these cities to the north of Scotland, in connexion especially with what is known as the "east coast" route. Instead of a single span of 600 feet, with two side spans of 300 feet, which was the scheme of last year, it is proposed to make four spans of 500 feet each over the navigable channel, the spans di-

minishing to 200 feet and 100 feet on either side. The clear height of the bridge in the channel will be 125 feet at high water of spring tides, thus giving ample height beneath for the tallest vessels frequenting the ports of Grangemouth and Alloa. The frame of the girders over the widest spans will be about 70 feet giving a total visible elevation of 195 feet for the distance of nearly half a mile, the height diminishing at the ends of the bridge as the spans become reduced in width. Taking the submerged part of the work, the height will be 25 feet of foundation below the silt bottom, 50 feet of depth of water at ebb spring tides, and 18 feet of fluctutation of tides, making in all 285 feet in height of work to be executed. The middle piers will be of stone to the height of 10 feet above high water at spring tides, and the rest of the structure will be of malleable iron. The bridge will be built for a single line of rails, with a gradient in the south end of 1 in 134, and in the north end of 1 in 100, so as to give the necessary elevation in the middle. The dimensions of the Britannia Bridge may be stated by way of contrast:—Span, 460 feet; height, 104 feet; depth of tube, 30 feet. The cost of the bridge is estimated at between £ 500,000 and £ 600,000, but, on the other hand, the companies would save the capital cost of piers, breakwaters, and steamboats, and cost of working the ferries. In connexion with the Tay Bridge an unbroken express line would be provided between Edinburgh and Dundee, saving the inconvenience, uncertainty, and delay of the Burntisland and Tayport ferries.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

No. 5.—*Fire Service and Hydrants.*

Continued from page 175.

Hydrant contingencies and defects.—The considerations of these points will be directed to the present forms, location, intervals, calibre, protection from frost, cases, and workmanship.

In the milder climate of the European cities, hydrant nozzles, encased at street grade and at street pavements are not as liable to obstruction from snow and ice, as in the more severe temperature of our Middle, Western, and Eastern States; and for this reason, mainly, they have not been adopted. The American hydrants, are placed along the curb lines of the sidewalk, and either "*flush*" with sidewalk grade, or with "*stand-pipe*" *heads*, the former being more common in the Eastern, and the latter in the Middle States, although the water administrations of the milder sections, object to the "flush" hydrant on account of winter weather. The more correct cause for their adoption, is to be attributed partly to the habit of following certain beaten paths, without much inquiry as to their alignment, and the desire to accede to the wishes and prejudices of the volunteer firemen, who exercise considerable rivalry in securing the first hydrants for their particular "machine," and have a special regard for those more readily found in the general race for precedence. In the hurly-burly of

a fire-alarm and of arrivals on the ground, a fireman looks more picturesque seated on the hydrant which he has secured for his "machine," and can maintain his position better against the next comers, than over a flush case, without such salient points; beside this it takes the hose a shade easier, he thinks, and it certainly looks better in the engraving of his certificate or the elaborate art adornments of his engine and engine house.

On this point, the Jersey City report says;—

"The kind of hydrant adopted here, and which has been used throughout the city, is the "flush hydrant," as it is called. Considerable fault has been found with them by the firemen, not in consequence of any failure to answer the purpose intended of them, but from a belief that they may cause some trouble and inconvenience, and perhaps also from a strong prejudice against them before they were put in operation. But, it is believed no trouble has yet been experienced with them, and that, if a fair trial is given they will prove satisfactory."

The firemen, in this case, made up their minds beforehand; but ten years actual experience has by no means vindicated their correctness; and the water-boards which adopt the logic of these firemen, as to flush cases, on the sidewalk, put down all their main-stop-cock boxes with flush heads, in the street centres or near the gutters, without a shadow of compunction over fixtures, which are of no less vital character. If in such cities as Boston, Charlestown, or Hartford, ice and snow are not serious obstructions to this particular form, they must be less so in cities of much milder temperature; if they are so located and cared for, as to be easily found; if less liable to freeze; if less costly and less liable to accident and less objectional to pedestrians, they have valuable qualities which should be discussed and admitted without prejudice, and particularly so, when the days of volunteer fire service are drawing to a close.

The matter of hydrant location, deserves greater care than it receives, and may be simplified by a general rule of position. If flush hydrants at street corners were invariably placed on the north-west and south-east corners, and on the west and east building ranges, at the curb line, they could be readily found; if those between the corners were placed near gas posts, or designated by house-marks, or placed midway for blocks over 200 and under 300 feet in length, and not over 200 feet apart in longer blocks, comparative strangers might readily find them, while policemen and habitues would never be at fault. As all hydrants are the subjects of special care and examination and as all sidewalks are required to be cleared of snow every morning, the flush cases need not be covered up by snow or ice so as to be at any time inaccessible. As they are shorter, warmer and cheaper and make their discharge with less friction, these advantages are in their favor. With low nozzle covers on stand-pipe heads, the plash from the gutter is apt to freeze them up, so as to require long wrenches to break the joint, in winter.

The relative *intervals* or distances between hydrants, have an important bearing on their usefulness in concentration of fire supply.

In London they are about 400 feet apart, while in Hamburg the intervals are 120 feet. In our own cities it is customary to call them

300 to 400 feet apart; in one report we are told that on the basis of 1853, Boston has a hydrant to every square of 212 feet, Philadelphia 270 feet, New York 323 feet, being 1137 hydrants to 51,000,000 sq. ft., 1015 to 76,000,000 sq. ft., and 1601 (1851) to 167,000,000 sq. ft. respectively; Baltimore and Albany were arranged on a basis of 300 feet square.

But if regard is paid to the average intervals, as determined by the number of hydrants connected with a given length of mains, we see that on their lines the intervals are much greater, being from 471 to 1530 feet.

The improvement suggested in action, requires in all denser localities, closer intervals. In every case there should be two hydrants at each street intersection; for blocks not exceeding two hundred feet this would answer without intermediates, and on long blocks the intervals, sbould not exceed two hundred feet; with two lengths of hose for the street corner, and two for each intermediate, two streams could be thrown into any building fronting on the street, from short hose lines, with great effect, and according to experience in other cities, in an average time of two minutes. Of the experience on this point, a few notes will suffice.

"In five cases out of six, the hose is pushed into a water-plug and the water thrown upon a building on fire, for the average pressure in this town is 146 feet; by this means our fires are generally extinguished even before the heavy engine arrives at the spot."—*Oldham Water Works, England.*

"Throughout the whole length of the pipeage, are placed at intervals of 40 yds., fire plugs of 3 inches diameter in the clear. A jet can be applied in two minutes, all the fires which have occurred repeatedly, have been put out at once. If they had had to wait the usual time for engines and water, say 20 minutes or half an hour, these might all have led to extensive conflagrations."—*Hamburg Water Works.*

"At each fire station, reels of hose, each mounted on a light hand cart or barrow are kept; the bottom of the barrow forms convenient lockers for containing the stand-pipe, nozzle and tools, and the whole apparatus is so light that a man can run with it. On notice of a fire being received at a station, a couple of men set out immediately with one of these reels, others follow, and the remainder of the force busy themselves in turning out the engine. * * * And it may be a dozen jets are playing and the flames nearly extinguished before the engines have left the yard. * * * Serious fires are now seldom heard of, for before the flames can gain head, the jets can generally be played upon them and this is the only time there is a chance of subduing them."—*Liverpool Water Works.*

"Fires have occurred in Gorbals where they have been got under and extinguished before the arrival of the engines and their attendant hose. This is a matter of great importance in all large towns where so much property is annually destroyed by the ravages of fire."—*Glasgow Water Works.*

Improved *calibre* furnishes the third link in this chain of progress, the friction of the common form of hydrant tubes being a formidable obstacle to their proper action.

The calibre of hydrant tubes and valve openings have been noticed in the case at Philadelphia, and is not exceeded as a rule; the Brooklyn tubes are three inches in diameter with an inch valve rod, which practically brings them below the former example.

In remarks on relative calibre of service mains, experiments were

noticed showing different effects on the same hydrant and base; at the same time experiments were made on hydrants.

In the case of the four inch main of 600 feet, from the 5 inch of 600 feet attached to the 9 inch main, the jet from one hydrant of $2\frac{1}{2}$ inch tube, in the clear, with 40 feet of hose and $\frac{7}{8}$ inch nozzle, rose 34 feet from the end of the service; with two hydrants and hose, the jets rose 23 feet; and this under a head of 120 feet on the connected lines of mains. Fixed near the 5 inch mains, one jet rose 40 feet and two, 31 feet.

The same attachments to the 7 inch main, gave for one hydrant in play a 50 feet jet, for two, 45 feet, for three, 40 feet, for four, 35 feet, for five, 30 feet, and for six, 27 feet; with one hydrant open, and 160 feet of hose, in place of 40, the jet rose 40 feet.

On the 9 inch main, one hydrant jet rose 60 feet, two, about the same height, four, 45 feet, and six, 40 feet.

We have here the effect of different lengths of hose, the jet of 50 feet, with 40 feet of hose, being reduced to 40 feet, with 160 feet, or 20 per cent.; we have also, the effect of additional hydrants, reducing the jet from 34 to 23 feet, from 50 to 27 feet, and from 60 to 40; the throw of 6 hydrants being $33\frac{1}{3}$ per cent. less than that of one on the 9 inch main, and 46 per cent. less on the 7 inch; we have also, a commentary on the severe loss by hydrant and hose friction, the greatest result from 120 feet head, being 60 feet, or 50 per cent. less, and this with one hydrant on a large main, with a short length of hose.

The Detroit Report for 1862 gives the following notes on the time of discharge for 100 gallons of water, through pipes, attached to the hydrants, of three sizes:

Order of Position.	Reservoir Head.	Time with Pipe of 1 inch.		⅝ inch.		¼ inch.	
		min.	sec.	min.	sec.	min.	sec.
15	33·1	1	19	2	32	14	4
14	34·6	1	32	2	46	14	28
8	36·0	1	32	2	51	14	20
7	39·0	1	27	2	38	13	4
16	42·0	4	31	5	55	28	14
12	43·5	1	58	3	41	18	51
9	48·7	1	53	3	17	17	6
6	49·7	1	35	3	4	14	54
4	49·8	1	40	2	59	13	42
3	49·9	1	24	2	25	12	43
13	50·9	1	16	2	11	10	40
10	51·0	1	45	3	9	16	0
11	53·1	1	45	3	9	16	0
5	67·5	1	16	2	22	12	26
2	72·7	1	14	2	9	10	37
1	74·3	0	47	1	43	8	54

This experiment cannot be rigidly analyzed, the results being affected by relative location in the general service of conditions of local draft. The Report says:

It will be seen by the above tests that the hydrant at the corner of Sprout street and Woodward Avenue, (No. 7), discharged 100 gallons in about two-thirds the time the same quantity was discharged from the one at the corner of Fort and First streets, (No. 12), notwithstanding the theoretic head is greater at the latter point, showing the loss by friction and draft, the former one being located near the large supply main with but few water takers in the vicinity, and the latter a mile from it, in a district consuming a large quantity of water, supplied by pipes of small diameter."

But it furnishes an interesting comment on the relative friction of discharge tubes, in the quantities of water deliverable, and on the vigilance of one of the most zealous water administrations of the country. In the same report a complaint is made, that under a reservoir level of 77·5 feet;

"The loss in the effective head of water in the central parts of this city, for want of sufficient capacity in the distribution service is from twenty to twenty-five feet."

At Wolverhampton, (England) with a head ranging from 200 to 100 feet, the $\frac{3}{4}$ inch hose jet rises 70 feet from the hydrant, and the hydrant power is stated at 50 per cent. greater than that of a 14 man-power engine. As compared with the London fire engines, one of 26 man power with two seven-inch barrels, produces a 50 feet jet.

At Brooklyn, the first hydrant opened for fire use, corner Schenck street and Myrtle Avenue, being about 120 feet below reservoir level, was obliged to be shut off to avoid washing Engine No. 10, which took its supply, after the fire with one length of hose it threw a stream 125 feet horizontally, with a $1\frac{1}{4}$ inch nozzle. At the water celebration the 7 inch jet of the City Hall fountain, rose within 11 feet of the reservoir head, more than 5 miles distant.

At Boston, the 6 inch jets on the Common, rose to 98 feet above tide, the reservoir flow line being 120.

Jet experiments by *Mariotte* with a circular orifice of 0·53-inch, gave the following results:

Head. feet.	Jet. feet.	Loss. feet.
37·7303	34·0886	3·6417
37·2382	33·1933	3·449
27·8220	25·8107	2·0113
26·0175	24·3443	1·6732
13·1564	12·7955	·3609
5·8728	5·7416	·1342
11·7128	11·2207	·5921

The last from *Bossut* for a vertical jet, became 11·3850 feet for a slightly inclined jet, illustrating the effect of the falling particles on the former, while all the results show the effect of friction at the orifice and atmospheric resistance. It is also laid down as a theoretical law, that "great jets rise higher than small ones; under the same head; having more mass, the resistance less promptly destroys their velocity, and they are less divided."

From these detached examples, several lessons may be learned. From the fact that 40 feet of hose, under certain conditions, threw 10 feet higher than 160, being a loss of ·083-foot per foot, the extravagant fiction of riveted hose is shown, as a good reason for reducing

the feeding lengths for jets or engines, by increasing hydrants; while the loss of head in the London experiments is excessive, it furnishes a clear argument in favor of larger hydrants in calibre,—and especially in the American types, of their delivery from the objectionable feature of internal working gear, around which the water must force its way, with aggravated disturbance; the same lesson of effect through contracted tubes is taught emphatically by the Detroit experiments, in the differences of discharge.

On the other hand, we see it demonstrated practically, as we know it to be theoretically, that it is possible, by a judicious arrangement of conduits, to realize the effects of reservoir head, within a reasonable and moderate per centage of loss, and this in such a way as to demonstrate an actual superiority of power, over hand engines, although these have always the advantage of superior concentration and choice of position, for special work. This possibility, once admitted, answers all objections of cost, or custom, or novelty in our proposed application for primary fire service; if the proposed results are within reach, the end justifies all the means. It is said that increasing draft in time vitiates reservoir head, and it cannot, therefore, be relied upon; increased feed service will readily meet this defect, by means always applicable.

The fact that one hydrant tends to draw down another, illustrated in the London experiments, does not involve a valid objection to primary dependence on hydrants, carefully designed and located, since it will evidently require a smaller supply of water to do the smaller amount of fire service actually involved, but this fact is an important condemnation of the present system of delivery to the hydrants.

Various water works reports hint at the difficulty, which, in the words of the Cincinnati Report for 1847, "is now experienced when more than one engine is attached to a pipe, in robbing each other, and all the hydrants in the neighborhood."

The general adoption of steam fire engines, places this and the other effects named in a more imperative light, since they are so much superior to the hand engines in capacity and regularity of discharge.

On this point the following extracts are instructive.

"A change has been made in the hydrants, so as to adapt them to the steam fire engines, as was recommended last year, and all the hydrants set in future will be of the improved pattern. In connexion with the hydrants, additional precaution has been taken to insure an abundance of water in case of fire, by connecting the following fire reservoirs (street cisterns) with the main pipes."—*Boston Report for* 1861, *p.* 27.

"Great difficulty has been experienced in procuring an adequate supply of water for them (steam fire engines); this has in part been remedied by applying the suction of the engine immediately to the plug; while this gives a much better supply of water, the ram or concussion produced by the operation of the pump, loosens the joints of the plug or some of the connexions, and in one instance the main was burst; to remedy this defect and also to give a more copious supply of water, the department has constructed a fire plug of much larger dimensions than that now in use, and which has the addition of an air chamber to it, to receive the ram of the water. It is hoped by means of this that the steam fire engines can be worked without the city being put to the expense of constructing large cisterns to pump from."—*Philadelphia Report for* 1858, *p.* 30.

"The distribution service should never be laid in populous districts with pipes less than six inches diameter, except when short lines are required, whereas pipes of four inches in diameter have been assumed as the minimum, and since the introduction of steam fire engines, experience has proven that a line of four inch pipe will not properly supply more than one engine."—*Detroit Report for* 1862, *p.* 23.

"A difficulty is experienced in procuring from the hydrants now in use a sufficient volume of water to supply the steam fire engines. The same difficulty is experienced in other cities where steam fire engines have been introduced. This difficulty has been overcome in Philadelphia, by the substitution of hydrants operating in all respects like the ordinary one, except that the size has been increased, so as to give a clear water way of four inches. * * * The hydrants are fitted with three discharge nozzles, two for ordinary hose connexions, and one for the suction of the steamer. The introduction of hydrants of greater capacity is required here."—*Detroit Report for* 1861, *p.* 30.

The *protection* of hydrants, and their feed lines, *from frost*, is a matter of great consequence. The depths at which service mains are generally laid, viz: four feet, is supposed sufficient for their protection; in Brooklyn, the branches were laid for a hydrant base five feet below grade; cases, however, have occurred where mains and branches of small calibre have frozen, want of circulation being the cause.

The Cleveland Report of 1856, says;—

"Notwithstanding this precaution, (four feet depth,) the unprecedented and continued freezing weather of the past winter penetrated the ground to the depth of the pipes and below them. Several of the small lines at particular points were frozen solid inside with ice which burst them. * * * Six fire-hydrant connexions were frozen by exposure from the depth of the street gutters. To prevent a recurrence, the 3-inch branch-pipes will be laid deeper in future."

Report for 1857;—

"By reason of there being so very few water takers last winter, there was scarcely any circulation or current in the street pipes; (in some streets no water was taken at all;) much trouble and inconvenience was experienced during the intense cold weather. Some of the distributing pipes froze solid and consequently burst."

Report for 1863;—

"The operation of thawing out hydrants was performed 334 times last winter."

At Detroit in 1856, one-half the drinking hydrants and house service pipes were closed by freezing, and among the wooden logs, laid at shallow depths, of $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ feet, four miles were entirely destroyed. The Report says;—

"The leaks from the freezing and bursting of iron pipes were comparatively few, and principally occurred where there was no circulation, and also where the streets have been cut down for paving since the pipes were laid. In one case where there was no circulation, a four-inch pipe, the top of which was four and a half feet below the top of the pavement, was frozen solid.

"As usual in this department, one man has been constantly employed in looking after and examining the fire-plugs and reservoir valves."

The cases of frost in service mains are exceptional and uncommon where much draft occurs, but the constant liability of fire-hydrants to freezing is well understood in all Northern cities. The Albany Report for 1859, says;—

"To maintain them in a working condition, daily examinations are necessary.

A few, in very exposed situations, are liable to be affected during severely cold nights, but early attention restores their efficiency, and preserves the pipes from disruption by the frost."

And the same rule holds in other localities. The Boston Report for 1858, says;—

"The usual precautions have been taken to keep the hydrants in order during the winter. They have all been cleaned and oiled, also well packed with salt hay. They are all examined once, and sometimes twice a day, during the coldest weather, to keep them free from ice."

Report for 1859;—

"The unusual cold weather in the present month of January has made it necessary to keep an extra force of men employed to keep the hydrants free from ice, and in good order for use in case of fire."

The Detroit Report for 1857, sums up several contingencies thus;

"Of the fire-plugs taken up and repaired, 6 were injured by freezing; 2 were broken in consequence of pebble-stones having been thrown in at the nozzle; the stones had fallen between the valves and seats, and in straining too hard to close the valves, they were broken off; one had the valve rod rusted off. The 7 fire plugs that were taken up and replaced with others, had been damaged by the frost past repair.

"Of the fire-plugs repaired without being taken up, 2 were broken by firemen; 5 were broken by frost; 2 were broken by cause not known. The 33 fire-plug boxes that were lowered and straightened had all been raised by action of the frost.

"From the above statement it will be seen that the action of frost is the principal cause of injury and damage to the fire-plugs. The fire-plugs in this city, which are the same as those used in every other city in the country, are unsuited to the severe tests of northern winters. A fire-plug that shall be so complete as to meet all the objections to the present kind, is a very great desideratum. From all places where they are used the same complaints are heard. The only remedies that appear to be applicable in their use, are to drain them, (as most of them are in this city,) and during freezing weather to allow none of them to be opened unless when required for use at fires."

The Chicago Report for 1861, says;—

"The number of hydrants taken out to be repaired was 55,or about one in 8½ of the whole number in the city. Considering how seldom these are used for fires, the number repaired appears large. * * * Much pains is taken to keep the hydrants from freezing, by packing around them with manure in the beginning of winter, and by frequent examinations during very cold weather. Most of those found frozen are in boxes that are not drained, and consequently partly filled with water. Where sewers have been laid near hydrants, it is most desirable that the boxes around the latter should be connected with the former, as in excessively cold weather it is impossible with a reasonable force to keep all the hydrants constantly free."

Several instances are reported of hydrants being broken by heaving the case against the nozzle under the action of frost.

The method of frost vent adopted at Detroit in 1855, is thus stated:—

"The old waste cock and rod are dispensed with, and a small brass plug, with a quarter inch hole through the centre, is driven in, in place of the waste cock. A short piece of lead pipe is soldered on to the brass plug, and connects with the drain outside of the wooden box which encloses the fire-plug. The wooden box is then filled with earth up to the nozzle of the fire-plug. Of course, a quarter inch stream of water is wasted during the entire time that each plug is in use. * * * 128 of the fire-plugs are thus drained."

It does not appear, however, in subsequent reports that this method, with all its waste, was effectual, although some of the contingencies named in a former extract may refer to some of the 74 hydrants not thus drained in 1855.

A hydrant tube which is entirely encased, so as to hold a stratum of air around it, is less exposed to frost than one with solid stand-pipe head; a hydrant tube filled with water to the nozzle, is subject to frost above its valve, while an empty tube and a low valve are not so; and a narrow tube, with a large iron rod within it, aggravates the liability to frost; freezing also occurs when a case is filled in whole or in part with water, or with saturated packing of any kind. In severe weather, and during protracted fire-service, hydrants are apt to be opened and shut off a number of times, for changes of hose or engines, and their liability to saturated cases is thus increased, at a critical time.

In the various devices invented to ensure the desirable frost vents, absolute certainty of operation is not only requisite, but there should be a certainty of drainage, and one process is incomplete without the other; both are sufficiently simple, to be had without much ingenuity, and a vent which operates with the valve rod and at no other time, is evidently to be preferred to the wasteful devices above quoted. Neglect of drainage at Albany involved a troublesome and expensive reconstruction; this was in a clay soil; in Brooklyn, with a gravely soil, the precaution was taken to lay drain pipes not less than six feet long with six inches fall, from the hydrant bases.

Drains should connect with the street sewers, and not only ensure the case vent in this way, but maintain a current of warm air which is thus illustrated in the Chicago Report of March 31, 1864;—

"About 100 hydrants have been connected with the sewers in such a way as not only to drain off waste and leakage from them, but to let warm air from the sewers circulate around them. Although the operation of thawing out hydrants was performed 334 times last winter, but one hydrant that was connected with the sewers was frozen, and that was owing to the drain-pipe having been obstructed."

For a frozen tube salt is frequently used; at Philadelphia a small boiler, easily transported on wheels, and so arranged as to apply a steam jet, inside and outside the tube, has been found a very effective corrective.

Hydrant *cases* are made both of wood and iron; as the special action makes them alternately wet and dry, durability is out of the question for the former material, and much trouble and expense is occasioned by its use. At Boston, as fast as the original cases decay, those which are substituted are Burnettized; in this way a cheaper case than cast iron and more permanent than the originals, is obtained. Some idea of city experience on this point is contained in the following statement;—

"Many of the upper boxes have been repaired, while some have been replaced with new ones. In some localities the boxes decay rapidly, requiring frequent examinations."—*Albany Report for* 1860.

"The total number of hydrants is 255. * * * A large number of the boxes were found broken and decayed, some entirely detached from their fastenings. These, where practicable, have been repaired, while new ones have been substituted for such as were found entirely useless. As these repairs employed a mechanic and assistant for a long period, the expenditure for the same is large compared with that of former years. Every hydrant in the city was examined and put in order."—*Idem.*, 1861.

At Boston 127 Burnettized boxes were substituted in 1856, 176 in 1857, 148 in 1858, 83 in 1859, 123 in 1860, and 129 in 1861, 786 in six years, or more than half the entire number in 1861.

Of 367 hydrants repaired at Brooklyn in 1863, 116 required new covers, 107 new caps, 35 new boxes, and 64 new fastenings.

It might be supposed, simple law of cause and effect being ignored, that the experience of any one city, would settle the farther continuance or acceptance of such appurtenances, some of which, as at Albany, positively encumber narrow side-walks with their large proportions; but they still "increase and multiply."

The more convenient and durable iron cases, are therefore much preferable on the score of economy, but in time are subject to the effects of oxidation. Brick cases might be built, of ordinary or curved bricks; but cases made of concrete, in the same way as the best kinds of sewer pipes, with iron covers, could be substituted in such way as to combine the best qualities of form, cheapness and durability. Pipes of this kind may be made oval or circular, of any desirable thickness and strength, and bear exposure to alternate moisture and dryness, or frost and heat, without injury.

The propriety of using salt, hay, manure, earth, &c., for packing, is questionable, when the operation of the frost vent saturates it. Frost then becomes more certain and more severe, and thawing more difficult; a confined air stratum is much better, and in itself, an effective non-conductor.

As in all other appurtenances used in controlling or conveying water under pressure, the *workmanship* of a hydrant should be carefully made. At Philadelphia and many other cities the contract system is ignored, and all such details are manufactured under the direct inspection of the proper officers. There is considerable difference in the work of hydrant builders, the more pretentious not being always the most faithful. As to the castings, the valve seats, nozzle-bosses, and working gear, the best materials should be used and fitted in the most accurate manner, to avoid the chapters of annual repairs contained in annual reports. To avoid water action on the internal rods and gearing the former should be coated with composition, and the latter made of the same material.

(To be continued.)

MECHANICS, PHYSICS, AND CHEMISTRY.

On Chemistry Applied to the Arts. By Dr. F. Crace Calvert, F.R.S., F.C.S.,

From the London Chemical News, No. 240.

Bones.—Composition of raw and boiled bones. The manufacture of superphosphate of lime. Application to agriculture. Bone black or char, and their use in sugar refining. *Phosphorus*, its properties, extraction, and employment in manufacture of matches. *Horn* and *ivory*, their composition and applications.

Lecture I.

I shall not take up your time by making many preliminary remarks, but merely state that though the heads of the subject on which I intend to speak are not inviting ones, still we shall find as we progress that the study of the various matters which I shall bring before you is full of interest and instruction. Further it would be difficult to name subjects which better illustrate the ability of man to turn to profitable account the various materials placed in his hands, or to mention substances which have received more complete and skilful applications than those we shall treat of this evening.

Bones.—The composition of "green bones," or bones in their natural state, may be considered under two general heads, viz :—the animal matters, consisting of a substance called osséine and a few blood-vessels, and the mineral matters, chiefly represented by phosphate of lime and a few other mineral salts. The composition of bones has been examined by many eminent chemists, but the most complete researches are those, published in 1855, by M. Fremy, who examined bones, not only from various classes of vertebrated animals, but also from different parts of the same animal; and to enable you to appreciate some of his conclusions, allow me to draw your attention to the following table:—*

Composition of Bones.

Name of Bone.	Mineral Matter.	Phosphate of Lime.	Phosphate of Magnesia.	Carbonate of Lime.
Femur—Fœtus 6 months,	63·0	58·9		5·8
" Boy 18 "	61·6	58·0	0·5	2·5
" Woman 22 years,	60·1	59·4	1·3	7·7
" Man 30 "	63·2	57·7	1·2	9·3
" " 40 "	64·2	56·3	1·3	10·2
" Woman 80 "	64·6	57·1	1·2	7·5
" " 97 "	60·8	51·9	1·3	9·3
" Lion (young)	64·7	60·0	1·5	6·3
" Sheep, . .	70·0	62·9	1·5	7·7
Sperm Whale, . .	62·9	51·9	0·5	10·6
Ostrich, . . .	70·0			
Carapace of Turtle, .	64·3	58·0	1·2	
Codfish, . . .	61·3			
Stag's horn, . .	61·9	58·1	traces	3·8
Cow's tooth, Bone, .	67·1	60·7	1·2	2·9
" " Enamel, .	96·9	90·5	traces	2·2
" " Ivory, .	74·8	70·3	1·3	2·2
Scales of the Carp, .	34·2	33·7	traces	1·1

* *Annales de Chimie et Physique*, volume xliii, pages 79, 83, 84.

The first conclusion drawn by M. Fremy from these researches is, that he found a larger proportion of mineral matter than is generally admitted by chemists. Secondly, that there is no material difference in the composition of various bones taken from different parts of man, or of any one animal, but that age had a very marked influence on composition. Thus, in the bones of infants there is more animal and less mineral matter than in the adult, whilst in old age there is more mineral and less animal matter than in the middle aged man. The mineral substance which chiefly increases in old age is carbonate of lime. Lastly, he could find no marked difference between the bones of man, the ox, calf, elephant, and whale; whilst in the bones of carnivorous animals and those of birds there is a slight increase in the amount of mineral matter. Allow me now to call your attention to a most interesting query. I hold in one hand the mineral matter only of a bone, which you can see retains perfectly its original form, and in the other hand I have the animal matter only of a similar bone, which also retains the form in which it previously existed, but is flexible instead of rigid. The question, therefore, arises, whether the strength and hardness of bones proceed from these two kinds of matter being combined together, or are their respective molecules merely juxtaposed? The answer is, the latter; for, as you see by this specimen, the mineral matter has been entirely removed without deforming the animal texture. Further, in the fœtus it is found that the bones contain nearly the same proportions of animal and mineral matters as those of the adult. Also, it has been observed by M. Flourens and other eminent physiologists, that the wear and tear of bones during life is repaired by the formation of new bone on the exterior surface of the bone, while the old substance is removed through the interior duct, and that the composition of the new layer is the same as that of the original bone. Let us now proceed to examine the chemical properties of the various substances composing bones, and some of the various applications which they receive in arts and manufactures. The general composition of bones may be considered to be as follows:—

BONES.

Organic Substances.	Blood-vessels,	1
	Osséine,	32
	Fatty matters,	9
Mineral Substances,	Water,	8
	Phosphate of lime,	38
	Phosphate of magnesia,	2
	Carbonate of lime,	8
	Various salts,	2
		100

The above-named animal matter, *osséine*,—

C	50·4
H	6·5
N	16·9
O	26·2

and which has been erroneously called gelatine, is insoluble in water,

weak acids and alkalies, whilst gelatine presents properties directly reverse. But what has led to this popular error is that osséine, when boiled in water, becomes converted into the isomeric substance commonly called gelatine. As I shall have to dwell on this substance at some length in my next two lectures, I will not detain you now further than to state that osséine is obtained from bones by placing them in weak hydrochloric acid, which dissolves the phosphate of lime and other mineral salts, washing the animal matter (osséine) until all acid is removed, drying it, and treating it with ether to remove fatty matters. I cannot leave this subject without remarking on the extraordinary stability of this animal substance, for it has been found in the bones of man and animal after many centuries, and even in small quantities in fossil bones.

The fatty matter of bones is made useful in the manufacture of soap, railway grease, and in other purposes; it is obtained by taking fresh bones (as bones which have been kept a long time will not yield their grease easily) and placing the spongy parts, or ends of the bones (where most of the fatty matter exists) in large boilers filled with water, which is then carried to the boil, when a part of the osséine is converted into gelatine, and the fatty matter liberated, which rises to the surface, and is easily removed. The bones thus treated are called boiled bones, and receive many important applications, to which your attention will be called in a few minutes. Benzine and bisulphuret of carbon have been used as substitutes for water in the above operation, but the advantages do not seem to have been sufficient to lead to their general adoption.

Mineral Matter of bones.—These, as the foregoing tables show, are chiefly represented by phosphate and carbonate of lime. The immortal Berzelius was the first to establish the fact that phosphate of lime was the only substance possessing the properties necessary for the formation of bone, owing to the extremely simple chemical reactions which cause the soluble phosphates to become insoluble. Let us trace shortly the sources from whence we derive the large proportion of phosphate of lime which exists in our frames. Several of our most eminent chemists have proved the existence of phosphorus in sedimentary and igneous rocks, and the important part played by phosphorus in nature cannot be better conveyed to your minds than by this extract from Dr. Hofmann's learned and valuable Report on the Chemical products in the Exhibition of 1862:—"Large masses of phosphorus are, in the course of geological revolutions, extending over vast periods of time, restored from the organic reigns of nature to the mineral kingdom by the slow process of fossilization; whereby vegetal tissues are gradually transformed into peat, lignite, and coal; and animal tissues are petrified into coprolites, which in course of time yield crystalline apatite. After lying locked up and motionless in these forms for indefinite periods, phosphorus, by further geological movements becomes again exposed to the action of its natural solvents, water and carbonic acid, and is thus restored to active service in the organisms of plants and lower animals, through which it passes, to complete the mighty cycle

of its movements into the blood and tissues of the human frame. While circulating thus, age after age, through three kingdoms of nature, phosphorus is never for a moment free. It is throughout retained in combination with oxygen, and with the earthy or alkaline metals for which its attraction is intense." After these eminently philosophical views by Dr. Hofmann, I will proceed to call your attention to the application of bones to agriculture. Bones are generally used for manuring in one of these three forms:—1st. As ground green bones; 2d. As ground boiled bones—(that is, bones nearly deprived of their osséine by boiling under pressure, as I shall describe in my next lecture); 3d. Superphosphate of lime.

Green or raw bones have been used on grass land for a long period, but their action is exceedingly slow and progressive, owing to the resistance of the organic matter to decomposition and the consequently slow solubility of the phosphate of lime in carbonic acid dissolved in water. What substantiates this view is that boiled bones are far more active than the above. It is found that 30 to 35 cwts. per acre of these will increase the crops on pasture land from 10 to 20 per cent. in the second year of their application. But the great advantage which agriculture has derived from the application of bones as a manure has arisen from their transformation into superphosphate of lime, especially applicable to root and cereal crops. To Baron Liebig is due the honor of having first called the attention of farmers (in 1840) to the importance of transforming the insoluble phosphate of lime of bones into the soluble superphosphate, rendering it susceptible of immediate absorption by the roots of plants, and of becoming at once available for their growth. These suggestions of Liebig were rapidly carried out on a practical scale by Messrs. Muspratt, of Lancashire, and J. B. Lawes, of Middlesex; and in consequence of the valuable results obtained by them, the manufacture of artificial manures has gradually grown into an important branch of manufacture in this country. The manufacture of superphosphate of lime is so simple that any farmer possessing a knowledge of the mere rudiments of chemistry can make it for himself, by which he will not only effect great economy, but also secure genuineness of product. All he requires is a wooden vessel lined with lead, into which can be placed 1000 lbs of ground boiled bones, 1000 lbs of water, and 500 lbs of sulphuric acid sp. gr. 1·845 (or concentrated vitriol), mixing the whole, and stirring well for about twelve hours. After two or three days a dry mass remains, which only requires to be taken out and placed on the land by means of the drill, or to be mixed with water and sprinkled on the land. When very large quantities of this manure are required, the plan devised by Mr. Lawes appears to me the best suited. It consists in introducing into the upper end of a slightly-inclined revolving cylinder a quantity of finely-ground boiled bones, together with a known proportion of sulphuric acid of sp. gr. 1·68. As the materials slowly descend by the revolution of the cylinder they become thoroughly mixed, and leave it in the form of a thick pasty mass, which is conducted into a large cistern capable of containing 100 tons, or a day's work. This is allow-

ed to remain for twelve hours, when it is removed, and is ready for use. Most manufacturers find it necessary to add to the phosphate of lime of bones other sources of phosphates, such as coprolites, or the fossil dung of antediluvian animals, which have been found in large quantities in Suffolk, Cambridgeshire, and elsewhere, and contain from 36 to 62 per cent. of phosphate of lime, and from 7 to 48 per cent. of organic matter. Others employ a mineral substance called apatite, containing about 92 per cent. of phosphate of lime, and found also in large quantities in Spain, Norway, France, &c. Others, again, employ guanos rich in phosphate of lime, such as those of Kooria Mooria Islands and Sombrero phosphates. The following is the average composition of the superphosphate of lime of commerce :—

Soluble phosphate, . . .	22 to 25 per cent.
Insoluble " . . .	8 " 10 "
Water, ...	10 " 12 "
Sulphate of lime, . . .	35 " 45 "
Organic matter, . . .	12 " 15 "

Nitrogen, 0·75 to 1·5 per cent.

The valuable and extensive researches of Messrs. Lawes and Gilbert and Messrs. Boussingault and Ville have not only demonstrated the importance of phosphates to the growth of cereal and root crops, but also that phosphates determine, in a great measure during vegetation, the absorption of nitrogen from the nitrates or from ammonia, as will be seen by the following table.

Amount of Nitrogen fixed by Wheat under the Influence of following Salts :—

	Without nitrogenated compounds.	With nitrogenated compounds.
Phosphate of lime and alkaline silicate,	8·15	20·08
Phosphate of lime, . .	7·25	19·17
Earth and alkaline silicates, .	5 71	11·16
Earth, . . .	3 00	9·50

Bone-black or Char.—In 1800 Löwitz made the interesting observation that wood charcoal possessed the remarkable property of removing coloring matters from their solutions. In 1811 Figuier also observed that animal black had far greater decolorating power than wood charcoal, and bone-black has consequently become one of the principal agents in sugar-refining, and has been the means, more than any other substance, of producing good and cheap white sugars. To give you an idea of the extent to which bone-black is used at the present day for decolorating purposes in the refining of sugar, I may state that in Paris alone it is estimated that about 11,000,000 kilogrammes of bones are used annually for that purpose. The preparation of bone-black is simple in principle. It consists in placing in cast iron pots about 50 lbs of broken boiled bones, that is, bones which have been deprived of their fat—of most of their osséine, and piling these pots in a furnace, where they are submitted to a gradually rising temperature during twenty-four hours, such as will completely decompose the organic matter, but not so high as to partly fuse the bones and thus render them unfit for their applications. But a more economical process is generally adopted. It consists in introducing the crushed bones into

horizontal retorts, which are themselves in connexion with condensers, the ends of which are brought under the retorts to assist by their combustion in the distillation of the animal matter. By this arrangement not only is char obtained, but oily matters which are used by curriers, and also ammoniacal salts employed in agriculture and manufactures. The extraordinary decolorating action of animal blacks may be considered as partly chemical and partly mechanical—mechanical because it is proved, by some interesting researches of Dr. Stenhouse, to which I shall refer further on, that the action is due to the minute division of the carbon and the immense surface offered by its particles to the coloring matter, char being composed of 90 parts of mineral salts to 10 per cent. of carbon. On the other hand, the action is proved also to be chemical, by the fact that water will not remove the coloring matter, whilst a weak solution of alkali will dissolve it. Dr. Stenhouse's valuable researches not only illustrate fully this fact, but also prove the possibility of producing artificially substitutes for bone-black. In 1857 he published a paper describing the production of an artificial black, called by him aluminized charcoal. This he obtained by mixing intimately and heating finely pulverized charcoal and sulphate of alumina, when he obtained a powerful decolorating agent containing 7 per cent. of alumina, and well adapted for decolorating acid solutions, such as those of tartaric and citric acids, in chemical works. He also prepared what he called coal-tar charcoal by melting one pound of pitch in a cast iron pot, adding to it two pounds of coal-tar, and mixing intimately into it seven pounds of hydrate of lime, then carrying the whole to a high temperature, allowing it to cool, and removing the lime by washing the mass with hydrochloric acid and then with water, when carbon in a high state of division was obtained, possessing powerful decolorating properties. The following series of experiments by Dr. Stenhouse perfectly illustrate the chemico-physical action of animal black as a decolorating agent. He boiled a certain amount of char and his two charcoals with a solution of logwood, then treated each black separately with ammonia, when the following results were obtained;—Aluminized charcoal yielded no color; bone-black but a slight amount; coal-tar charcoal large quantities. But it would be wrong in me to leave you under the impression that animal black can only remove colors from solutions. Purified animal black—that is to say, animal black deprived of its mineral matters by the action of muriatic acid and subsequent washing—has the power of removing certain bitters from their solutions. Thus Dr. Hofmann and Professor Redwood applied this property with great skill some years ago to the detection of strychnine in beer. Again, Thomas Graham, Esq., Master of the Mint, published a most interesting series of researches, in which he established the fact that purified animal black had the power to remove a great number of saline matters from their solutions, such as the salts of lime, lead, copper, &c.

Revivification of Bone Black.—After a certain quantity of syrup sugar has percolated through the cylinders containing bone-black, the interstices become so clogged with impurities that it loses its power

of decolorating the syrup. Sugar refiners are therefore in the habit of restoring the power of their bone-black, generally speaking, by submitting it to a process of calcination, which volatilizes or destroys the organic matter fixed by the char. It has been proved by experience that char may undergo this operation about twenty times before its pores become so clogged with dirt as to render it useless. [Here the lecturer described, with the aid of drawings, several of the various apparatus used in sugar refineries for the above process, alluding particularly to that of Messrs. Pontifex and Wood, by which a ton of char is revivified every 24 hours.] A new process, however, has been devised by Messrs. Leplay et Cuisinier, which as a whole deserves the attention of refiners, though I am aware that several of the details of their process have been used for some time. The char which has served its purpose in the cylinders, instead of being removed, is treated at once by the following processes:—It is first thoroughly washed, treated by steam to remove all viscous substances, then a weak solution of alkali is allowed to percolate through the char, which remove saline matters and a certain amount of coloring matter, when it is further acted upon by weak hydrochloric acid, which in removing a certain amount of the lime salts, liberates the coloring matter; the char is again washed with weak alkali to remove the remaining coloring matter, and lastly the decolorating power of the black is restored by passing through it a solution of biphosphate of lime. It is to be hoped that the high praise bestowed upon this process on the Continent may induce our manufacturers to try it, as they would obtain two distinct advantages by its use. First, the economy of operating at once upon the black and restoring its properties without removing it from the cylinders. Secondly, the prevention of the noxious odors given off during the revivification of char by the ordinary methods. It is interesting to note one of the results of the different employment of char in this country and on the Continent. In England the wear and tear in sugar refinery is constantly repaired by the introduction of fresh char, and there is no spent or old char for sale. In France, on the contrary, owing to the great impurities in their beet-root sugar syrups, and to the use of blood in refinery, the char become rapidly clogged with organic matter, and is so completely animalized, that its value as a manure exceeds what the char originally cost the refiner. The result is that the French "spent" char is annually exported to the French colonies to the amount of 120,000 tons, and is there used as a manure to promote the growth of the sugar cane. So important is this article of commerce considered, that the French Government have appointed special analytical chemists to determine its value for the trade.

Phosphorus.—I am now about to call your attention to one of the most marvellous and valuable substances ever discovered by chemists. In 1660, Brandt, a merchant of Hamburgh, discovered a process for obtaining phosphorus from putrid urine; but though he kept his secret, a chemist named Künckel published the mode of obtaining it from this fluid. A hundred years later, Gahn discovered the presence

of phosphorus in bones; and Scheel shortly afterwards gave a process to obtain it therefrom. The process devised by this eminent chemist was shortly afterwards improved upon by Nicolas and Pelletier, and their method was so completely worked out by Fourcroy and Vauquelin, that it is still the process used in the present day. The preparation of phosphorus consists of four distinct operations:—1st, 80 parts of thoroughly calcined and pulverized bones are mixed with 80 parts of sulphuric acid, sp. gr. 1·52, to which is then added 400 parts of boiling water; 2d, after a few days the clear liquor, containing biphosphate of lime, is removed from the insoluble sulphate, and evaporated until it has the specific gravity of 1·5; 3d, this liquor is mixed with 20 per cent. of finely pulverized charcoal, and the whole is dried at a moderately high heat; when, 4th, it is introduced into an earthenware retort, placed in the galley furnace, and, on heat being slowly applied, phosphorus distils, and the operation is continued at a high heat for several days. It is, however, necessary that the phosphorus thus obtained should be purified, this is effected by melting the phosphorus under water, and pressing it through a chamois skin. It is then boiled with caustic alkali to remove other impurities, but what is still better is to heat the phosphorus with a mixture of bichromate of potash and sulphuric acid. The phosphorus thus purified is drawn through slightly conical glass tubes by the suction of a caoutchouc pouch, or is allowed to run, by an ingenious contrivance, into tin boxes. As will be seen by the following formula, the manufacturer only obtained from the bones one-half of the phosphorus they contain:—

$$2\,(PO_5,\,3\,CaO) + 4SO_3HO = 2\,(PO_5CaO,2HO) + 4\,(SO_3CaO).$$

Bone phosphate of lime. — Sulphuric acid. — Acid phosphate of lime. — Sulphate of lime.

$$2\,(PO_5CaO) + 5\,C = PO_52CaO + 5CO + P$$

Bi-phosphate of lime. — Carbon. — Pyro-phosphate of lime. — Oxide of carbon. — Phosphorus.

Consequently many attempts have been made to devise a chemical reaction by which the whole of the phosphorus might be secured. The most successful attempt of late years is that made by Mr. Cary-Montrand, whose process is based on the following chemical reaction:—

Action of Hydrochloric Acid on Bone Phosphate.

$$2\,(PO_5CaO) + 4HCl = 2\,(PO_5,CaO,2HO) + 4CaCl$$

Bone Phosphate of lime. — Hydrochloric acid. — Acid Phosphate of lime. — Chloride of Calcium.

Action of Hydrochloric Acid on Bi-phosphate.

$$2\,(PO_5,CaO) + 2HCl + 12C = 2CaCl + 12CO + 2H + 2P$$

Bi-phosphate of lime. — Hydrochloric acid. — Carbon. — Chloride of Calcium. — Oxide of Carbon. — Hydrogen. — Phosphorus.

He arrived at this result by treating calcined bones with hydrochloric acid; the liquor is then mixed with charcoal, and the whole dried at

a moderate heat. The prepared mass is then introduced into cylinders through which a stream of hydrochloric acid is made to percolate, and, as shown above, chloride of calcium, hydrogen, carbonic oxide, and two proportions of phosphorus are produced. (The process of Fleck was also described.) Phosphorus prepared and purified by the above processes is a solid, semi-transparent body, having a sp. gr. 1·83, fusing at 110·5° F.,and boiling at 550°. It is so inflammable that it ignites in the open air at several degrees below its fusing point; but Professor Graham made, some years ago, the interesting observation that this slow combustion of phosphorus could be entirely checked by the presence of certain combustible vapors. Thus he found that one volume of vapor of naphtha in 1820 of air, or one volume of vapor of oil of turpentine in 4444 of air completely prevented the spontaneous combustion of phosphorus. Further, phosphorus presents the curious property that, if heated to 160° F. and suddenly cooled, it becomes black, and if heated to 450° or 460° for several hours it becomes amorphous, and of a dark brown color. This allotropic state of phosphorus, first noticed by Schrotter, has enabled it to render great service to society, owing to its not being spontaneously inflammable (as, in fact, it only becomes so at a temperature approaching its point of fusion), and also to its not being poisonous, so that it can be substituted for common phosphorus in the manufacture of matches with great advantage. Lastly, owing to this brown amorphous phosphorus not emitting any vapors, those employed in the manufacture of chemical matches now avoid the risk of the dreadful disease of the jaw-bone, called phospho-necrosis. Notwithstanding the great difficulties attending the manufacture of this valuable product, Mr. Albright, of Birmingham, has, with praiseworthy perseverance and great skill, succeeded in obtaining it perfectly pure on a large scale, and at such a price as to bring it within the scope of commercial transactions.

Chemical Matches.—Although I do not intend to enter at great length upon this subject, yet, as is a highly important one, I deem it my duty to lay a few facts before you. The first application of chemistry to the discovery of a substitute for the old tinder-box of our fathers, was made in 1820, when the sulphuretted ends of matches were covered with a mixture of chlorate of potash, licopodium, and red-lead, and the matches so prepared were dipped into asbestos moistened with sulphuric acid. In 1836, lucifer matches were first introduced, and the explosive matches were soon followed by the non-explosive ones. The composition of these matches is as follows:—

	Non-Explosive.	Explosive.
Phosphorus, . .	25 or 30	9 or 4
Red lead, . . .	5 " 20	16 " 3
Nitre, . . .	0 " 0	14 " 10
Sand, . . .	20 " 20	
Vermillion, . . .	1 " 0	
Gum or glue, . .	20 " 25	16 " 6

The danger as well as the disease attendant on this manufacture was greatly mitigated by Professor Graham's discovery of the property of

turpentine vapor already alluded to. Until lately the only successful application of amorphous phosphorus to lucifer matches was that of Messrs. Coignet, Frères, of Paris, who caused a rough surface to be covered with it, and so prepared their matches that they would not ignite except when rubbed upon the prepared surface. Similar matches under the name of "special safety matches," have also been introduced into this country of late by Messrs. R. Letchford and Co., who have also effected several important improvements in this branch of manufacture, in one of which paraffine is made use of to carry combustion to the wood, instead of sulphur, which gives rise to the noxious fumes of sulphurous acid, and as the substitution is made by Messrs. Letchford without any increase of cost, the price of these matches is as low as that of the common ones. These gentlemen have also found the means of diminishing the amount of phosphorus used to a very considerable extent, so that the disagreeable smell of this substance is also avoided. But the greatest improvement that Messrs. Letchford have made is in what they call their hygienic matches, or lights, in which, for the first time, amorphous phosphorus is substituted for ordinary phosphorus, and in small quantities. The advantages of these matches cannot be overrated, for children can eat them with impunity, as amorphous phosphorus is not poisonous; they are not nearly so combustible, and, therefore, not so likely to cause accidental fires; and lastly, all source of injury to the health of those employed in the manufacture is removed. I cannot leave this subject without still drawing your attention to one or two important facts. Messrs. Hochstetter and Canouil, besides others, have lately introduced chemical matches free from phosphorus, which are stated to have the following composition:—

Chlorate of potash, . . .	10	10	10
Hyposulphide of lead, . . .	26	26	20
Peroxide of lead, . . .	—	9·8	—
Peroxide of manganese, . .	—	—	33·6
Chromate of lead, . . .	17	4	8·8
Gum arabic, ...	4	4	4

An important improvement in the manufacture of chemical matches is the reduction of the proportion of phosphorus to a minimum. This is effected by reducing the phosphorus to an infinitesimally minute division, by which the manufacture is rendered more economical, and the matches, when ignited, have less of the unpleasant odor, of phosphorus. This division is accomplished by using a solution of phosphorus in bisulphuret of carbon, by which a saving of $\frac{1}{2}\frac{9}{0}$ths of the phosphorus is obtained. Another invention is that of Messrs. Puscher and Reinsch, who have proposed the employment of sulphide of phosphorus.

Ivory.—The lecturer, having given some details respecting the properties of ivory, said: I will now call your attention to the substitution of the following mixture for ivory tablets as applied in photography. Finely-pulverized sulphate of baryta is mixed with gelatine or albumen, compressed into sheets, dried, and polished; these sheets are ready for use in the same way as ivory plates. You are all doubtless

aware that the nut of the *Phytolephas macrocarpa*, of the palm tree tribe, has for many years been used in this country as a substitute for ivory, and it may be interesting to you to be made acquainted with the two following facts, viz., that the nut is composed of—

Pure cellulose,	81 per cent.
Gum,	6 "
Nitrogenated principles,	4 "
Water,	9 "
Total,	100

and Dr. Phipson has recently published a method of distinguishing this vegetable ivory from the animal one by means of sulphuric acid, which gives a beautiful purple color with the vegetable ivory, but none with the animal ivory.

Horn.—The best quality of horns, and especially the beautiful ones obtained from the buffaloes in India and America, receive a great variety of application at the present day, owing to their great toughness and elasticity, as well as to their remarkable property of softening under heat, of welding, and of being moulded into various forms under pressure. To apply horns to manufacture they are treated as follows:—They are first thrown into water, and slight putrefaction commences, by which ammonia is produced, when the horn begins to soften. To carry this action further the horns are transferred into a slightly acid bath, composed of nitric and acetic acids, with a small quantity of various salts. When the horns are sufficiently softened, which requires about two weeks, they are cleaned and split into two parts by means of a circular saw, and these are introduced between heated plates, and the whole subjected to an intense pressure of several tons to the square inch. The plates may be moulds, and thus the horn may be compressed into any required shape. A great improvement has recently been effected in this branch of manufacture, which consists in dyeing the horn various colors. To accomplish this the horn is first dipped into a bath containing a weak solution of salts of lead or mercury, and then rubbing upon the horns impregnated with metallic salts, a solution of hydrosulphate of ammonia, when a black or brown dye is produced. Another method consists in mordanting the horn with a salt of iron, and dipping it in a solution of logwood. Of late, very beautiful white fancy articles have been produced from horn by dipping it first in a salt of lead and then into hydrochloric acid, when white chloride of lead is fixed in the interstices of the horn, which then simply requires polishing.

This lecture, as well as those which followed, were illustrated by numerous specimens and experiments.

(To be continued.)

What is an Inch of Rain?

From the Journal of the Society of Arts, No. 639.

The last weekly return of the Registrar-General gives the following interesting information in respect to rain-fall:—"rain fell in London

to the amount of 0·43 inch, which is equivalent to 43 tons of rain per acre. The rain-fall during last week varied from 30 tons per acre in Edinburgh to 215 tons per acre in Glasgow. An English acre consists of 6,272,640 square inches; and an inch deep of rain on an acre yields 6,272,640 cubic inches of water, which at 277·274 cubic inches to the gallon makes 22,622·5 gallons; and, as a gallon of distilled water weighs 10 lbs, the rain-fall on an acre is 226,225 lbs avoirdupois; but 2240 lbs are a ton, and consequently an inch deep of rain weighs 100·993 tons, or nearly 101 tons per acre. For every 100th of an inch a ton of water falls per acre." If any agriculturist were to try the experiment of distributing artificially that which nature so bountifully supplies, he would soon feel inclined to "rest and be thankful."

Rain.

From the Journal of the Society of Arts, No. 640.

In the *Journal* of last week, under the title, What is an inch of rain? appeared an extract from the weekly return of the Registrar-General respecting the rain-fall. M. Petit, the director of the Observatory of Toulouse, speaking of the late heavy rains, says: "The quantity is not so unusual as at first sight would appear. The average annual fall is about 60 centimètres, rather more than two feet English, spread over about a hundred rainy days, thus giving an average fall of about six millimètres for each day, or about six litres, 10 to 11 pints English, per square metre. The average of the heavy rains of the 15th, 16th, and 17th of January, in the present year, rose to about nine millimètres. Greater falls have often occurred in France. On the 19th of September, 1844, 35 millimètres of rain fell at Toulouse in thirty minutes; and on the 10th of August, 1859, there fell 59 millimètres in two successive storms of about forty minutes each in duration. . . In recalling the impression of terror created by the sight of a precipice one is inclined to ask how it is that we are not terrified at such enormous quantities of water being suspended over our heads. But the question appears under a still more extraordinary aspect when we consider the amount of heat required to vaporize all the water which we receive in the form of rain. When we remember that in the tropics there falls about two metres of water per annum; that in our climate we have never less than 50 or 60 centimètres; and that the masses of snow in the polar regions must also furnish a great quantity of water, it will readily be admitted that the annual rain-fall must be, at least, equal to a stratum of water all over the globe of 50 centimètres, upwards of 19½ inches English. . . . It is easy, with these facts given, to see that the evaporation caused by the heat of the sun must render to the atmosphere about 175,000,000,000 cubic metres of water per day, or rather more than 2,000,000,000 of litres a second. . . . And yet the furnace is 38 millions of leagues distant from us!"

The Invention of the Screw Propeller.

From the London Mechanics' Magazine, February, 1865.

The well-known story of the king who, when he wished to read any of the historical works in his library, used to request his attendants to hand h m his liars, seems likely to be repeated in the history of inventions. The future historians of achievements of this kind have a difficult task before them. They will have to meet all sorts of difficulties. However many lying *Te Deums* or thanksgivings may be proffered up for soi-disant victories, the truth about such an event as a great battle must, sooner or later, leak out pretty clearly. Not so with a great invention; and every civilized nation puts forward a separate claimant for almost every separate scientific victory. And then we know precisely what does constitute a victory by the force of arms; but we have not yet settled what constitutes an original invention. Is the first inventor the man who first has the idea, who first makes a sketch of the new thing? Or is it the man who first practically demonstrates it, and who then—like many inventors—throws it aside? Or is it the man who first clearly sees the commercial value of the thing (for an invention without any commercial value is still-born), and who dins this estimate into everybody's ears? Is the first inventor the man who first makes a drawing of the thing? or he who first makes it? or he who first (say) forms a company to work it? Does carrying out a thing, and then throwing it to one side, do away, more or less, with the first claim to the invention?

If we take, amongst other inventions, that of the screw propeller, we find that it is claimed by almost every great nation. England, France, America, Germany, and even Sweden, all enter the lists, and it is also claimed by the Chinese. Much might be said on this matter, but the rules as to scientific priority, in pure science, can scarcely be said to be laid down, and the question of scientific priority becomes doubly complicated when applied to technical matters. Of all claimants for inventions the most enterprising annexations of this kind are conducted by the French. It need scarcely be said that claims are made in France for this invention also. The chosen one is M. Frederic Sauvage, who, on the 28th of May, 1832, obtained a French patent for propelling a boat by two screws, one working under each quarter. A yet earlier proposition, however, for the adoption of the screw for ships was made in Germany. On the 11th February, 1827, an Austrian patent was granted to Joseph Ressel, an Austrian, for his invention of the Archimedian screw propeller, to be placed in the dead wood of the vessel; or for the use of two screws, one to be placed under each quarter. The Federal Diet have erected a statue to his memory at Trieste, and the Austrians another one at Vienna. In the latter city it is placed in front of the Polytechnic Schools. Some five years ago the Emperor of Austria also granted a pension for life to Ressel's widow.

In none of these cases does anything seem to have been carried into practical effect. If a mere sketch of the first idea is a sufficient basis

for a national claim of this kind, we may point to the correspondence of Watt, more than a century old, as containing a very clear drawing of a "spiral oar." This was very much like the screw patented by Mr. Lyttleton in 1794, and long after by Mr. F. P. Smith. A specification of 1800, in the name of Shorter, also shows a two bladed propeller. The next was the patent by Richard Trevithick in 1815. Mr. Wilson, now of Patricroft, states that he experimented with screw propellers in the years 1812, 1825-7, and that his plan was proposed to Government by the Earl of Lauderdale, with the usual negative result. It was publicly tried, and he was rewarded for its success by the silver medal of the Society of Arts. Mr. Wilson then seems to have given up the thing, and to have settled down at Patricroft. Other Scottish engineers also experimented with screw propellers in 1829 and 1830. Records of their trials may be found in the Transactions of the Scottish and of the London Societies of Arts. All these practical doings were remote enough from the date at which the invention, or at least the introduction, of the screw propeller is generally fixed. But we have heard from a very good authority in such matters, that the late Mr. Stevens, of New York, the same wealthy inventor who first experimented with iron-clads, also, as long ago as 1812, or thereabouts, actually built and worked a screw propeller at Hoboken. If this be the case, it is to be hoped that a full account of his doings will soon be laid before the public. There is a *prima facie* probability here in favor of Mr. Stevens, in the mere fact that he was wealthy. As a rule those who invent have not the money to try and prove their ideas, while those who have the money do not care to invent—such favorites of fortune find things pretty well as they are already. But in the very fact of not caring for gain, and only seeking a sort of elevated pleasure in invention, they do not care to introduce their inventions. This seems to have been the case with Mr. Stevens, and the battle of the introduction and indeed the invention of the screw propeller, had to be fought over again.

In an article which appeared in the *Times* lately, on the "Patriarchal Engines at South Kensington," an erroneous statement is made with reference to the introduction of the screw. The writer says, "that to Mr. Pettit Smith, the present Curator of the Patent-Office Museum, belongs the credit of placing the screw propeller in the dead wood of the ship, *the only spot* in which it can work *effectually*, and of asserting the value of the new principle so long and so loudly as to force it upon the attention of the Admiralty." Now it so happens that the Screw Propeller Company, who bought Mr. Smith's patent, brought an action, in the name of their secretary, Buck, against Steinman, for placing the screw in the position in which screws are now generally worked. This cause was tried before Lord Chief Baron Pollock and a special jury, on the 10th January, 1846, in Westminster Hall, and it was then clearly shown that placing a screw behind the stern-post of a ship and before the rudder, was not the discovery of Mr. F. P. Smith. This position for placing the screw was shown, not only in the specification of Charles Cummerow's patent, in 1828, but also in Mr.

Bennet Woodcroft's specification of 1832—in the first case eight, in the second, five years before the date of Mr. Smith's patent. The chief particulars of this case will be found at page 48 of our 44th volume. In the summing-up the judge observed "that the great question was whether, where a vessel had been lengthened out beyond the ordinary dead wood, as in this case, and had had the screw fitted into that elongated part, that application could, in truth and fairness, be considered a violation of Smith's patent." The jury "found that the screws in the vessels named were not fixed and worked in the dead wood, and, secondly, that there was not a colorable evasion of Smith's patent in the mode by which the screw was applied to the same vessel." It is clear to any one who looks at the drawing attached to Mr. Smith's specification that he does not place the screw behind the stern-post, where propellers are usually worked. In fact, he places it so far in front of the stern-post and under the ship, that, in a vessel of 300 feet long, the screw would be more than 20 yards in front of the stern-post, and in a part of the ship where its diameter would necessarily be so small as to render it of little, if any, effect as a propeller. Again, the screw opening shown by Cummerow and others, and adopted by Mr. Smith, after having abandoned his own scheme, is not in "the only spot in which a screw can work effectually." Now the first boats practically propelled by screws had them working, not only behind the stern-post, but even behind the rudder. Again, it has been proved by Mr. Richard Roberts, that two screws, one under each quarter, form a better arrangement than one, and it seems likely that the place in a ship where screws have hitherto been worked will be now abandoned. The chief propelling power in Mr. Smith's company consisted in its aristocratic elements. The company's steamboat, the "Archimedes," made her first experimental trip on or about the 14th of October, 1839; and when these trials were over, the engines were taken out of her and she was sold for a sailing vessel.

It would have been contrary to the fact to suppose, as is asserted by the *Times*, that the Admiralty adopted the screw propeller in consequence of the "long and loud assertions" of its value made by Mr. F. P. Smith's company, or by an inspection of the "Archimedes." In fact, two years before, the Lords of the Admiralty had been towed in their own barge from Somerset House to the works of Mr. Seaward, and back, and at the rate of ten miles an hour, by a screw propeller boat the "Francis B. Ogden," made by Captain Ericsson. Amongst those present on this truly important experimental trip were Sir Chas. Adams, Senior Lord of the Admiralty, Sir William Symonds, the Chief constructor of the Navy, Sir Edward Parry, Captain Beaufort, and the designer of the vessel, Captain John Ericsson. The British Admiralty took no further notice of the invention at the time, but the experiment was being watched by a captain of the United States Navy, then in London, who saw the value of the invention for ships of war as well as for other vessels. He immediately ordered an iron screw boat from Captain Ericsson, and to be named after himself, the "Robert F. Stockton." This vessel was, probably, the first practical

screw propelled boat that the world ever saw, and it was most certainly the first vessel of the kind ever set to work in British waters.

The undivided honors of having built the first practical screw steamer, the first screw war ship and the first cupola war vessel, thus belong to Captain John Ericsson. The "Robert F. Stockton" having demonstrated to English engineers the value of the screw propeller, sailed from England to the States in April, 1839. A special Act of Congress was obtained to allow her to ply in American waters and her name was changed to that of the "New Jersey. Before Captain Ericsson's departure for America he built another propeller boat termed the "Enterprise," for Mr. John Thomas Woodhouse. She first ran as a passenger boat on the canal at Ashby-de-la-Zouch, and she is stated to have been afterwards employed as a tug on the Trent and Mersey for a certain coal traffic, and with great success. This vessel actually begun to work before the "Archimedes" was constructed. If Mr. Smith had never once made experiments with a screw propeller, there would have been at this moment just as many boats propelled by a screw. On his arrival in the States, Captain Ericsson built the first screw vessel of war, the "Princeton," and she was launched in the month of April, 1842. Not even Mr. F. P. Smith could persuade the British Admiralty to try the screw, and Captain Coles was as unsuccessful with his cupola vessels. That the screw propeller has been applied to vessels of war; that the cupola system has been tardily and reluctantly tried, are due to the lessons, or rather warnings, wafted over the Atlantic. About a year after the launching of the "Princeton," we got our "Rattler," and just as the "Warrior" and her sister ships are British offspring of the "Gloire" and the other French iron-clads, so shall we be some day indebted to the American "Dictator," and her compeers for a trial of the cupola system.

Another error in the *Times* article consists in ascribing to Mr. F. P. Smith the construction of "the screw of the 'Rattler' which, in the water tournament, so signally defeated the paddle steamer 'Alecto.'" If the writer in the *Times* had only taken the trouble to open the catalogue of the museum, or make an inquiry of Mr. F. P. Smith himself, he would have seen that the screw in the Patent-Office Museum which performed the above feat was furnished by Mr. Woodcroft. This screw was made under a patent which he obtained in 1832 for an increasing pitch screw, and for which propeller the Admiralty paid him £220. This very patent was also prolonged for six years, although the prolongation was opposed by Mr. Smith's Screw Propeller Company. During the trial its relative merits, compared with the "Archimedean" screw, patented by Mr. F. P. Smith, in 1836, and previously patented by Wm. Lyttleton, in 1794, drew from Lord Brougham, one of the Judicial Privy Council then sitting, a remarkable expression of opinion. He said "as to the merits of the invention:—In this case there appears to be no doubt whatever; the evidence of all the scientific men, and all the practical men who have been examined before their lordships, appears to prove that it is an invention, we should say, as far as it appears before us, original, and also, as it appears before

us, of very considerable merit and value. It appears to my mind that there is a clear step made in the progress of steam navigation, and in the construction of that very useful implement in steam navigation, the "screw" for the purpose of propulsion. It is introducing a new mathematical principle as well as a new mechanical principle, and I hold it to be a highly important improvement." When the "Rattler" was commissioned she was first furnished with three screws. One of these was that by Woodcroft, now in the Patent-Office Museum, another by Smith's Propeller Company, and one by Blaxland or Steinman. All the three were necessarily tried by the "Rattler" at Portsmouth before she joined the experimental squadron. Woodcroft's screw proved to be the best, and the two others were stowed away and never afterwards used. Captain H. Smith, the commander of the "Rattler" stated, in his sworn evidence before the Judicial Privy Council, "that she had been commissioned in 1844, by him. Several screws had been tried on her, and lastly that of Mr. Woodcroft. The results had been very good indeed." The following was a memorandum made at the time of the results which it had exhibited: "I think Mr. Woodcroft's spiral propeller superior to any yet tried in the 'Rattler.' It has less vibration, less fuel is consumed, with fewer revolutions and greater speed; consequently there is less slip. On the 25th of February, the result of going with a head wind blowing hard was better than any before." Mr. Langlands, the chief engineer of the "Rattler," was sworn, and stated, "that Mr. Woodcroft's screw gave greater speed, with fewer revolutions, less vibration, and used up the power of the engine better." It was by means of this screw that the "Rattler" was enabled to tow the "Alecto," and it drove the "Rattler" until she was no longer fit for service. If the *Times* would make use of its own old files, it would find that on the 4th of July, 1846, in speaking of the experimental squadron, then in the Bay of Biscay, it says that "with the exception of the "Rattler," which is, we believe, fitted at this time with Woodcroft's screw propeller, and which distinguishes herself on all occasions, under sail, as well as steam, the large steamers have proved large encumbrances to the fleet." The subsequent history of the screw propeller is, like most other histories of the kind, that of a succession of British and foreign patents.

New Safety Light for Coal Mines.

From the London Athenæum, Feb., 1865.

MM. Dumas and Benoit have been making some experiments in the French collieries on the application of electricity as an illuminating power in "fiery" coal mines. Voltaic electricity has been proposed on several occasions, as a means of giving light to the collier in dangerous places. But, under the ordinary conditions, it has not been found practicable to employ it. Dumas and Benoit propose to apply Rhumkorff's coil machine and Geissler's tubes; to use, indeed, those tubes, with their beautiful auroral light, as a miner's lamp.

The tube, it is now generally known, is filled with some highly rarefied gas, and platinum wires are hermetically sealed into the ends. When the discharges from a Rhumkorff's coil apparatus are passed through this tube it becomes filled with a mild, diffusive light, which lasts as long as the discharges pass through the rarefied medium. This light is unaccompanied by heat; it cannot, therefore, under any circumstances, explode the fire-damp of our coal mines.

This new "safety lamp" consists essentially of a cylindrical zinc vessel about 6 inches high and 4 inches in diameter, which incloses a porous vessel holding a cylinder of carbon. A solution of the bichromate of potash is placed *in* the porus cell, and dilute sulphuric acid *without* it. This battery is secured by a wooden cover, which is, by means of india rubber packing, made to fit closely. Then there are a Rhumkorff's coil and condenser, and a Geissler's tube. This tube is arranged into a conical coil, so that a large surface of light is secured within a small space. Of course the objection to this will be the cumbrous character of the machine and its adjuncts. Dumas and Benoit think they have answered this objection by the very ingenious arrangement which they have secured. We are assured that the weight of the glass case does not exceed two pounds, and that of the other parts of the apparatus is not more than twelve pounds. That there are many advantages in this electrical lamp cannot be denied. But we doubt if so delicate a machine can be intrusted to the hands of colliers. Under circumstances of danger, such a lamp as this would prove of the highest value. As Dumas and Benoit are making practical trials of their "cold light" as they call it, we shall, if they are successful, hear more of this interesting application.

The Institute of France has given the inventors a prize of 1000 francs for the ingenuity of their plan. We understand that some trials have been made in the Newcastle collieries. The objection raised by the miners is, that the light is a "glimmer"—not a steady illumination.

For the Journal of the Franklin Institute.

The Economy and Safety of different Modes of Traveling. By Wm. Bouton, University of Michigan.

The purposes of the traveler are so various that the mode which is most economical for one purpose may be very expensive for another. If the purpose is to storm a battery, there is no way quite equal to going on foot.

Some noted travelers have commenced their career by journeying on foot over the most populous countries of Europe, and have even had the audacity to recommend it as the fittest mode for one, who wishes to see the sights and learn the customs of those nations.

If a man should set out to seek the head-waters of the Nile with the thought that civilized man had never trod the path before him, a *locomotive engine* would be as much out of place in his outfit as a panorama of Paradise Lost printed on six thousand feet of canvass.

But these purposes generally involve the common desire to reach the journey's end with the greatest possible *rapidity*, *ease*, and *safety*, and with the least *cost*.

The mode of travel which at the same time secures all these requirements in the highest degree will be preferred. Or since perfection cannot be attained, a great gain in one, speed for example, will be chosen at some loss in another, as safety.

What are the exact equivalents of each, in terms of the other, or how far any one of them may be sacrificed for a given gain in another, it is difficult to say. It rather is evident that no two men would judge of them and agree. One man thinks more of his ease: another will make great exertion to avoid most distant danger: a third values his time and is willing to take greater risk, so he can accomplish more. Yet all will agree practically, that speed, safety, ease, and cost of travel, are each convertible in terms of the other between *some* limits. The prudent man never lived who would always drive a spirited horse at a walk, though it might be much safer to do so.

Formerly, perhaps yet, public opinion regarded railway traveling as much more dangerous than the time-honored system by stage coaches. Men traveled by railroads nevertheless, and stage coaches had to migrate. This does not prove, that when men made the charge against railroads, of greater danger, they were insincere. They valued the increased speed and cheapness as well as ease, more than they regarded the difference in safety. A journey of 300 miles, but an ordinary day's ride by rail which gave the night for rest, would consume four or five days in comparatively hard work by stage, and without half the certainty of making connexions between different lines. The stages charged *six* cents a mile more or less for fare, the railroads charged *three* cents. These advantages, too palpable to be overlooked, revolutionized the world's travel. Greater *safety* was not generally believed in.

If now it shall appear by an examination of statistics that the danger of accident on railroads is really much less than by the old methods or by existing modes of canal and river packets, it will result that in speed and safety, as to cost and comfort, railroads stand pre-eminent.

A railroad accident occurs; everybody hears of it. The newspapers are filled with glaring capitals and detailed accounts of how it all happened. Who ever heard of a stage coach accident being published outside the county journal. The impression gains that railroads are very destructive to life.

To judge justly let us reduce the statistics to some standard of comparison. When we can get the necessary data, let us compare the number of casualties with the whole number of miles traveled on any road. This ratio is more satisfactory than any other, for we wish to know the danger in accomplishing a given journey, whether it be crowded into a day or spread out over a week.

On the railroads of New York State in 1853, a little more than twelve millions of passengers were carried an aggregate distance of 531,512,298 miles, 15 persons were killed, or 1 in 35,434,153 miles

traveled. But a large majority of these accidents resulted from getting on or off the train when in motion, standing or lying on the track and the like. If we exclude these, but three fatal accidents remain or 1 in 177,170,766 miles traveled. In the Cyclopædia of Commerce, 1860, I find that in New York, for a series of years, the average loss of life was 1 person killed for 47,164,426 miles traveled. If, as before, we exclude accidents arising from the sufferer's own carelessness the ratio is 1 in 235,822,132. These results are tabulated from the State Reports. In the same publication for the year 1863, I find that Dr. Lardner has estimated the chances of a fatal accident per mile of railroad travel, 1 to 65,363,735. The chances of injury, 1 to 8,512,486. Such an estimate from so eminent an authority is entitled to much weight. We see that the range is very wide; we should also find the danger on some roads and in some sections of country uniformly greater than in others.

Taking Dr. Lardner's estimate and allowing 300 miles as a day's work, traveling by rail, a person must travel 597 years before there would be an expectation of a fatal accident, (I refer here to the mathematical and not the moral idea of expectation.) Reductions on the same basis, from some of the figures given above, would give over 2000 years before the expectation of a fatal accident to the traveler on those roads. Are not fatal accidents quite as common in the ordinary business of life, as on railway trains?

In Hunt's Merchants Magazine, vol. xxxix, page 249, a table is given of the casualties from railway traveling in England, Scotland, and Ireland for the years named, formed by dividing the total number of passengers by the number killed, as follows:—

Year.	Ratio as above.	Year.	Ratio as above.
1850	6,071,202	1855	11,859,513
1851	4,494,268	1856	16,168,449
1852	8,913,572	1867	5,200,000
1853	2,841,296		
1854	9,529,907	Mean,	8,137,276

In order to compare this table with the results given above on other roads, I find in the Cyclopædia of Commerce for 1859, data from which it results that the average distance traveled by each passenger in the United Kingdom during this time was 16 miles very nearly. Hence we find that there was one fatal accident in 130,196,416 miles traveled.

The following table shows the comparative safety of railway traveling in different countries, compiled, the writer says, from the statistics of a series of years. It would seem that there must have been a very large proportion of wounded to make these figures agree in the case of England with those just given for Great Britain. Hunt's Merchants Magazine, vol. xxxix, page 504.

Prussia,	1	killed or wounded for		3,294,075	carried safely.
Belgium,	1	"	"	1,611,237	"
France,	1	"	"	375,092	"
England,	1	"	"	311,345	"
United States,	1	"	"	188,459	"

In seeking an explanation for these figures I have found that the average travel of each passenger in the United States is about forty miles while in Great Britain it was but 16 miles, or if we multiply the ratio in the United States by the average distance traveled by each passenger, we shall have for the ratio of casualties to the whole distance traveled, $188{,}459 \times 40 = 7{,}538{,}360$. A little more than 12 per cent. more disastrous than the mean given by Dr. Lardner.

How was it in the good old times of stage-coach traveling? Statistics were rare. I have been able to find the following:—

On French railroads 212 miles in length, of 1,889,718 passengers who traveled over 316,945 miles, in the first half of 1843, not one was either killed or wounded, and only three servants of the railroad suffered. Comparing with this, the traveling by horse coaches in the *same region* we find that in seven years, from 1834 to 1840, 74 persons were killed, and 2073 wounded.—*Gillespie's Roads and Railroads.*

In Hunt's Merchants Magazine, vol. xxxix, I find that under the postal system of France, 1846 to 1856, of 7,109,276 passengers, 20 were killed and 238 were wounded. This was after railroads were introduced which accounts for the small number of passengers, but I do not quite see how it accounts for the large proportion of accidents,—1 killed or wounded for 27,555 carried safely. More than six times as disastrous as the worst show that has been made among all the systems of railroads examined. On an American railroad, traveling 30 miles an hour a traveler is safer than in a French diligence, traveling 5 miles an hour!

If we consider fatal accidents only, the ratio is 1 to 355,463, more than $22\frac{1}{2}$ times the ratio of fatal accidents to the number of passengers on railways of Great Britain for the same period!

Some of the reasons for this great difference are the system to which railroad management has been reduced so as always to fix the blame where it belongs; the great strength with which the cars are made so as even to collide at high speeds and only smash the engine and baggage car; the smoothness of the road, freeing the wheels and axles from such severe jolts and strains as they are liable to on common roads; the centre of gravity of the cars is lower, hence they are less liable to be overturned, the engine does not take fright and is at least more manageable than a vicious horse.

The following statistics of the loss of life by *steamboat* accidents may be interesting. The figures include the lake, river, and harbor casualties of the United States in the years mentioned.

1853	576 killed.	1857	303 killed.
1854	587 "	1858	364 "
1855	176 "		

We see that the loss of life was on the whole decreasing while the travel was increasing. I think it is evident that the proportionate

loss of life is greater than on railroads, though I have been unable to determine the total amount of travel.

The statistics of canals which I have found, refer to the economy with which they carry freight and not their value as lines of travel.

The following table gives the number of casualties from railroad accidents in the United States for eight years.

Year.	Number killed.	Number wounded.	Number of Accidents.	Average No. killed and wounded at each accident.
1853	234	496	138	5·28
1854	196	589	193	4·07
1855	116	539	142	4·61
1856	195	629	143	5·77
1857	130	530	126	5·24
1858	119	417	82	6·54
1859	129	411	79	6·83
1860	57	315	74	5·03

These figures show that while the number of miles of railroad was increasing 2000 to 3000 miles a year, and the old roads were increasing their business, still the number of casualties very steadily decreased. The last column shows that the accidents which did occur were as serious in 1860 as 1853 and 1854. Has this ratio decreased since that time?

In Great Britain from 1854 to 1860, after their railroad system was nearly completed, the yearly travel increased eight per cent. per annum. I cannot find as definite statistics for this country, but if we consider how each new road adds to the business of the whole and the rapid increase of the population, we shall be safe in assuming that on the old roads in this country the travel increased ten per cent. per annum for the same period. Combining with this the fact that from 1853 to 1860 the total length of railroads in the country increased from 17,000 to 31,000 miles and it will result that in 1860 the railway travel in the country was 3½ times what it was in 1853. If the number of accidents had maintained the same proportion, we should have had in 1860, 483 accidents and 819 lives lost by them, instead of 74 accidents and 57 lives lost. Even 1865 does not threaten to compete with 1853 in the danger of railway traveling. And in that year railroads were several times safer than any other mode of travel known.

If other testimony were wanting to prove the safety of railroad traveling, we might mention that in England, companies insure against loss of life and proportionately against injury from railroad accidents.

On a trip from London to Liverpool, 1 penny insures against loss of life for £ 500, and their reports show that for dividends, the stocks of the insurance companies are better than those of the railroads.

New Boiler Regulations in France.

From the London Artizan, Mar., 1864.

A ministerial decree has been issued in France relative to steam boilers. The following is a *résumé* of the chief instructions issued:—

Every boiler, new or old, before it is delivered by the constructor, repairer, or seller, is to undergo a proof under the direction of Mining or Ponts et Chaussées engineers. This proof consists in submitting the boiler to a pressure, double of what it is not to exceed when it is working, for all boilers of a working pressure between half a kilogramme and 6 kilogrammes per square centimetre (7·1 lbs and 85·3 lbs per square inch) exclusively. The surcharge of proof for pressures under these limits is to be constant and equal to half a kilogramme per square centimetre ; for pressures higher than the superior limit the surcharge is to be 6 kilogrammes per square centimetre. The proof is to be made by hydraulic pressure kept up as long as is necessary for the examination of all parts of the boiler. If the proof be satisfactory, a stamp indicating in kilogrammes per square centimetre the effective pressure that the steam should not exceed, is to be affixed to the boiler in such a manner as to be visible after it has been put in place. Two safety valves are to be provided for each boiler, to be weighted so as to allow the steam to escape before, or at least as soon as, the pressure arrives at the quantity marked on the stamp, placed in view of the fireman, showing the pressure of steam in the boiler. All boilers are to have apparatus of sufficient and effective power for supplying water to them. No steam boiler, to be employed in a building, is to be established without a declaration being made to the prefect of the department. Certain boilers are to be established only outside a house or workshop having an upper story where workmen are in regular employment. No boiler of the first class is to be placed at a less distance than 3 metres (9 feet 10⅛ inches) from a neighbor's habitation. All furnaces of boilers, of whatsoever class they may be, are to consume their own smoke. Six months delay is accorded to manufacturers to whom no notice was given at the time of authorization, to execute these last dispositions. The boilers of portable engines are to be submitted to the same proofs, and furnished with the same safety apparatus, as boilers established in a fixed place ; so also are locomotive engines.

For the Journal of the Franklin Institute.

On the Means Adopted in the Factories at Lowell, Massachusetts, for Extinguishing Fire. By JAMES B. FRANCIS, Civ. Eng.

The first cotton mill at Lowell went into operation in the year 1823 : it was provided with force-pumps which supplied a cistern in the roof and a hydrant in each story. There were no hydrants outside of the building. All the cotton mills erected in Lowell previous to the year 1828 were protected in the same manner. In January of that year a mill was burned down, and the want of some more efficient means for extinguishing fire was clearly shown. The plan was then adopted of laying an eight-inch main pipe through each mill yard, about forty feet in front of the mills ; this pipe was furnished with hydrants, and was connected with the force pumps and roof cisterns of each mill, so that all the apparatus on the premises could be brought to bear on any one mill. When the force pumps were not in operation, the supply and pressure of water in the mains depended entirely on the cisterns, but

by means of a peculiar system of valves at the cisterns, a pressure equal to a head of one hundred and fifty feet, could be maintained in the main pipes when the force pumps were in operation.

The next improvement of importance was made in the years 1847 and 1848, when the main pipes in the several mill yards were connected, so that, as far as the capacity of the eight-inch main pipes would permit, the force-pumps in all the mills in the city, could be brought to bear on any one mill. In 1849, a reservoir was constructed on an elevation about a mile from the nearest mill, and connected with the main pipes in the mill yards by means of a twelve-inch pipe, through which the water passes, either from the mill yard mains to the reservoir, or the reverse, according to circumstances. When full, this reservoir contains about two millions of gallons, and gives a head in the main pipes in the mill yards, of from one hundred and eighty to two hundred feet. The supply of water in the reservoir is maintained by means of force-pumps, erected for the purpose, driven by water power. It was originally designed to limit the use of this water to the purpose of extinguishing fires; the high and constant pressure afforded, however, great advantages for supplying the steam boilers used for heating purposes in the mills. Water is drawn from the mains in most of the mill yards for this purpose. About a dozen dwelling houses are also supplied, and small quantities are occasionally drawn for building, and other purposes. The whole quantity drawn for other than fire purposes is, however, too small sensibly to affect the pressure in the pipes. The city having no public water works, urgent applications have been made for the privilege of tapping the pipes, but they are jealously guarded, as the efficiency of the whole system depends in a great degree upon maintaining a constant high pressure in the mains, which the experience of other cities, shows can scarcely be done, if the water is generally used for domestic purposes.

Previous to the year 1850, the large manufacturing corporations at Lowell had seldom effected any insurance on their property, against losses by fire, but had relied upon laying aside a portion of their earnings, as an insurance fund, to meet such losses as might occur. An efficient system of watching had been adopted from the first, and great care was constantly exercised in guarding against fire and in keeping up the apparatus for extinguishing it. In the year 1850, they entered into an agreement for mutual insurance; some modifications indicated by experience have subsequently been made in it; as now in force it imposes very little restraint upon the manufacturing operations, and provides for the distribution of all losses, among the co-insurers, in proportion to the irrespective capital stocks. Nothing, however is paid on losses of less amount than one thousand dollars, and no member is obliged to contribute more than two per cent. of its capital stock, on account of any one loss.

The aggregate amount of the capital stocks of the co-insurers is $13,600,000, and the amount of loss by any one fire, covered by the mutual insurance, is $272,000. Only the property within the limits of the mill yards is covered by the mutual insurance; no exact esti-

mate of its aggregate value has ever been made, but when the usual stocks of materials and goods are on hand, it is supposed to be equal in value to about three-quarters of the capital stocks, or $10,200,000. The whole number of losses covered by the mutual insurance during the fourteen years and ten months since its adoption, ending April 14th, 1865, was fifteen, amounting to $141,818·32; the average annual loss being $9,560·79. If the value of the property insured is taken as above stated, the average annual loss has been a little less than one-tenth of one per cent.

The mutual insurance agreement provides a mode for ascertaining the amounts of losses, and also, for frequent inspections of the apparatus for extinguishing fire, and for the ejection and withdrawal of any of its members. Since this arrangement was entered into, there has been much interest felt in perfecting the apparatus, and great expense has been incurred in so doing. The lines of pipes through the mill yards and the connexions from one yard to another, made an irregular line of eight-inch pipe, about three miles in length, having a general horse-shoe form; the connexion of this line with the reservoir was at one point, near the toe of the shoe; in the year 1853, an important improvement was effected, by connecting the ends of the horse-shoe line, by a pipe of the same size, about three-quarters of a mile in length. Since this connexion has been made, the water drawn in any mill yard, from the reservoir, passes through the twelve-inch pipe to the eight-inch pipe, thence through both branches of the eight-inch pipe, to the place of delivery, or a point near the same. In each mill yard there are several sets of force-pumps, driven by water power, these are kept ready for immediate use; the water thrown by them is discharged directly into the eight-inch main pipe, and any excess of water, not drawn from the main passes up to the reservoir.

Each mill yard is supplied with numerous hydrants; on an average one to about every fifty feet in length of the main pipe at the front of the mills, and nearly as many at the rear; about one-third of these hydrants have one hundred feet of hose and a hose pipe constantly attached; these are protected from the weather by small buildings, in which the hose is hung ready for instant use. Supplies of hose are kept at hand for use at the other hydrants, and ladders with platforms at each story are fixed at several places on the sides and ends of the buildings; these serve for fire escapes for the operatives, as well as for purposes connected with extinguishing fire.

Lines of pipes, about four inches in diameter, are carried from the mains into the mills, passing up to the top, and having a hydrant at each story, with hose and pipe constantly attached.

As a rule, there is such a line at each stairway, the pipe and hydrant being placed inside the rooms, as near as practicable to the head of the stairs. This situation is preferred, as it enables the operators of the apparatus, to remain longer at their posts, and with more sense of security, than they could do at points from which escape would be less easy and certain. The mills built previously to 1845, were generally about 156 feet long, 45 feet wide, and four stories high, besides basement and attic; these mills have usually one stairway, placed in a

projection or porch in the middle of the front. Mills of later construction are generally larger, and have two or more stairways, and a corresponding number of lines of pipes and hydrants. These pipes are constantly filled with water under high pressure, and the hydrants are kept ready for instant use.

It has been found by experiment that in one of the mill yards, least favorably situated, four of the hydrants outside of the mills, discharging through three-quarter inch nozzles, could be supplied at one time, and throw water to a vertical height of about seventy-five feet above the nozzles; when the number was increased to eight, the vertical height to which the water could be thrown was reduced to about sixty feet. In this experiment none of the force-pumps were in operation, the entire supply being drawn from the reservoir. In some cases, when the force-pumps in several mills were in operation, twenty-five or more hydrants have been effectively used at once. In case of fire, the nearest apparatus is got into use as soon as possible, and if there is any probability that a larger quantity of water will be wanted than can be supplied under a suitable pressure from the reservoir, the force-pumps in one or more of the mills are put in operation; if a very large quantity is wanted, the force-pumps in mills in other parts of the city are put in operation. A frequent result in such cases is that the quantity of water in the reservoir is greater after the fire than before; this arises from a greater number of force-pumps being put in operation than necessary, the excess of water pumped passing up to the reservoir. Safety-valves, similar to those used on steam boilers, are applied at several points on the eight-inch main pipe, to relieve it from excessive pressure due to the action of the force-pumps.

Sprinklers, within a few years, have been extensively introduced into the Lowell Mills, and in connexion with the system of reservoir and mains, are considered the most effective means known for extinguishing fire. In some of the departments of a cotton mill, fire spreads over a whole room with such rapidity, that hydrants or other ordinary means, seem to be wholly inadequate to extinguish it. In such case, a suitable sprinkler appears to afford the greatest protection practicable.

As constructed at Lowell, a sprinkler consists of a net-work of pipes perforated with small holes, so arranged and directed that when a valve connecting the sprinkler with the main pipes is opened, the water will flow into all parts of the system of pipes, and escape at the perforations, with sufficient force to wet thoroughly, and in a very short time, every part of the room it is designed to protect. The idea is not new or peculiar to Lowell,* but perhaps it has been more extensively and

* A patent was granted in England in 1806, to John Carey, LL. D., of London, "for an invention of various contrivances for preventing or checking fires," &c. The invention first described in his specification is for a "shower bath for apartments, warehouses, &c. This is substantially the same apparatus as the sprinkler, with the exception that Carey's contrivance is intended to be put in operation by the fire itself. The cock by means of which the water is admitted to the apparatus containing the perforations for distributing the water, is furnished with a horizontal lever and a weight, sufficient to open the cock. This weight is held up by a cord which passes over different parts of the room; if this cord is burned off at any point, it allows the weight to fall and open the cock.

Repertory of Arts, &c., volume x, second series, London, 1807.

systematically adopted there than elsewhere. It was first introduced at Lowell, in the year 1845, into the picking-room of the Suffolk Manufacturing Company, by Mr. John Wright, the agent of that company.

As is well known, this department of a cotton mill, is peculiarly liable to fire, from the action of the machinery on the cotton, and particularly on the foreign substances which are often found mixed with it.

After the construction of the reservoir, the advantages of the sprinklers, when used in connexion with it, were so obvious, that they were soon introduced into the picking departments of all the cotton mills in Lowell. In 1852 and 1853, sprinklers were put into the roofs of the mills. In one of the old mills, which have slated roofs, the plan adopted was to carry a six-inch pipe, from the main in the mill yard, up near the middle of the mill to the level of the perforated pipe, which was placed a few feet below the ridge pole, and extended the whole length of the mill, in a single line, gradually diminishing in size, from five inches in diameter, near the middle, to three inches at the ends. This pipe was perforated with two holes, $\frac{3}{16}$-inch in diameter, in each foot in length. These holes point in different directions, so as to wet, as far as practicable, all parts of the roof. The water after striking the roof, falls, and a large portion of it finds its way into the stories below. The valve connecting the sprinkler with the main pipe, is placed in or near the ground, usually in a pit in the ground, near the mill, so as to be always readily accessible, and the water being constantly maintained in the main pipe at a high pressure, the sprinkler can be put in operation with very little delay.

The roof sprinkler is deemed a very great security against heavy losses by fire, as it affords the means of applying a large volume of water at the top of the mill, where from the elevation it would otherwise be difficult to apply it. This apparatus is expected to discharge about four hundred gallons of water per minute, and is intended to be used only for a few minutes at a time, unless the fire is confined to the roof. Its efficient action requires that most of the hydrants should be shut off.

Between the years 1853 and 1859, sprinklers had been introduced into many of the carding and spinning rooms of the cotton mills, which rooms are particularly liable to the rapid spread of fire. In the year 1859, sprinklers were required to be put in all such rooms, as well as into all picking rooms, and all other buildings and rooms liable to the rapid spread of fire or of difficult access.

It has been found by experiment that about four hundred and fifty gallons per minute is the largest quantity of water which can be drawn from the main pipes in some of the mill yards, from the reservoir alone, and maintain an effective working pressure. If a large fire should occur at a time when the canals are drawn off, as they often are during the night and on holidays, to enable repairs to be made, the force-pumps could not be operated, and the supply of water would be limited to that which could be drawn from the reservoir. By operating one

section at a time, the sprinklers can be effectively used in such an event; but in a large fire, the supply of water would be much too small for the efficient action of all the apparatus provided. The remedy is a larger main pipe, an improvement we are looking forward to in order to perfect the system.

As an illustration of the arrangement of sprinklers adopted at Lowell, the following description is given of the apparatus in the Tremont Mill, which was erected in the year 1863.

The building is about 440 feet long, and 70 feet wide inside; with five full stories and a roof nearly flat. The floors are of wood, supported by two rows of pillars. The beams are about 16 inches deep, placed about 8 feet apart. The floors are made of three-inch planks, laid directly on the beams, with a boarding above, and another below, between the beams, forming the ceiling. The three upper stories are furnished with sprinklers, arranged in three sections in each story. Each section is supplied by a rising main pipe, of cast iron, 6 inches in diameter, connecting with the eight-inch main pipe in the mill yard, and furnished with a stop gate, placed in a pit in the ground, deep enough to be completely protected from frost. The handle of the stop gate is constantly attached to the gate, and extends above the level of the ground, so as to be readily accessible at all times. The rising main pipe is carried up outside of the mill wall, and between the windows, in order to be out of the way of heat, when not filled with water, in case of fire in the mill. Near the level of the perforated pipes in the third and fourth stories, the rising mains are carried through the wall and connect, on the inside, with the horizontal mains, which lie just below the floor beams, and close to the wall of the mill, and extend each way as far as the section of sprinkler extends, or about 70 feet. The horizontal mains diminish in size as they recede from the rising main. At intervals of about eight feet, corresponding to the bays of the mill, lines of perforated wrought iron pipes branch off from the horizontal main, first upwards, by short vertical pipes, equal in length to the depth of the beams, in order to reach the level of the ceiling between the beams; thence across the whole width of the mill, in the middle of each bay, the pipe being in contact with the boards forming the ceiling of the room. The diameters of the perforated pipes diminish as they recede from the horizontal main, being 1½ inches in diameter at the origin and ¾-inch in diameter at the other extremity. The perforations are one-tenth of an inch in diameter, 18 inches apart on each side of the pipe, making about 92 perforations in each line. These holes point a little above the horizontal, so that the jet of water will strike the ceiling a few inches from the pipe. The water issuing with considerable force, it will follow along the ceiling, falling in drops at short intervals, a portion of it reaching the beams, which are about 3½ feet distant, on each side of the perforated pipes.

In the upper story, the ceiling rises in the middle, corresponding to the pitch of the roof; the horizontal main is placed in the middle of

the room, with the small pipes branching out on each side, and perforated the same as in the stories below.

The whole length of perforated pipe in the three stories of the mill is a little more than two miles, each section having about 1260 feet, containing about 1650 orifices. In one section, the total area of the orifices for the distribution of the water, is about 13 square inches; the sectional area of the rising main, is about 28 square inches; the proportion of sectional area in the rising main to the sum of the areas of all the orifices of distribution, being a little greater than two to one. In proportioning the diameters of the pipes throughout the whole system, substantially the same proportion is observed; thus, in the lines of perforated pipes across the mill, the sum of the areas of all the orifices of distribution is about 0·723 square inches; the sectional area of the pipe at its origin is 1·767 square inches, which is rather more than double the sum of the areas of the orifices of distribution. If the pipe at its origin had a diameter of 1·357 inches, its area would have just been double that of the sum of the orifices, but this is a size not usually manufactured. Of course there is no objection to the use of a pipe somewhat larger than the rule requires.

The pipes and perforations in each section of the sprinkler, are designed to discharge about 450 gallons of water per minute, which is about all that can be drawn from the main pipes in the mill yards from the reservoir alone, and maintain a sufficient working pressure; and of course, only one section at a time can be efficiently operated, unless the force pumps in that mill, or in some of the neighboring mills, are in operation.

The area of floor covered by one section of the sprinkler is about 10,300 square feet. The water discharged in one minute, would cover this area to the depth of about $\frac{1}{11}$ of an inch, which is at the rate of $4\frac{2}{7}$ inches per hour. The fall of water in a thunder shower is sometimes as great as this, but in this latitude it is very rare. There has been no opportunity as yet, to test the effect of any of the larger sprinklers, like that just described, in extinguishing a fire; many of the smaller sprinklers in the picking-rooms have however been used, and their operation has been in the highest degree satisfactory. There have been several opportunities for testing the larger sprinklers when there has been no fire; in every case, where the proportion between the sectional area of the pipes, and the area of the orifices of distribution which they supply, has been not less than two to one, the operation has been satisfactory, and in cases where sprinklers are in the lower stories, with short and well arranged supply pipes, they have operated satisfactorily, with a proprotion between supply pipe and orifices, of four to three. The proportion of two to one is, however, preferred. At Lowell the surface of the water in the reservoir is about one hundred feet above the top of the highest mill in the city. In order that sprinklers should operate with equal efficiency, with a less elevated reservoir, the proportion between the sectional areas of the supply pipes and the orifices of distribution should be proportionally

greater. In cases where the reservoir is but little above the level of the top of the building, a proportion as large as four or six to one may be necessary.

The following table is computed for the proportion between the sectional area of the supply pipe and the sum of the areas of the orifices which it supplies with water, of two to one. For a proportion of four to one, the number of orifices which can be supplied is one-half that given in the table; for a proportion of six to one, the number is one-third that given in the table.

Diameter of supply pipe.	Number of orifices of distribution of different sizes which can be supplied.					
Inches.	$\frac{3}{16}$ inch.	$\frac{5}{32}$ inch.	$\frac{1}{8}$ inch.	$\frac{1}{16}$ inch.	$\frac{3}{32}$ inch.	$\frac{1}{16}$ inch.
8	908	1312	2048	3204	3644	8195
7	696	1004	1568	2452	2788	6274
6	511	738	1153	1802	2050	4610
5	355	513	800	1251	1424	3201
4½	287	415	648	1013	1152	2592
4	227	328	512	801	911	2049
3½	174	251	392	613	697	1568
3	128	185	288	450	513	1153
2½	89	128	200	313	356	800
2	57	82	128	200	228	512
1⅞	43	63	98	153	174	392
1½	32	46	72	113	128	288
1¼	22	32	50	78	89	200
1	14	20	32	50	57	128
¾	8	12	18	28	32	72
½	3	5	8	12	14	32

Another Novelty in Cars and other Carriages.

From the London Artizan, Mar, 1865.

"A Patent Carriage Company, Limited," has been formed at Birmingham, for the purpose of bringing into use sundry novel improvements. The framework is of angle iron, welded. By using this several inches of space are saved, and added to the accommodation. The panels, which in ordinary cabs are of wood, in these new ones are of papier mâché. The paper resembles leather, but is stiffer and very tough. Every part of a cab usually of wood, indeed, is in this instance made of paper. The springs are beneath the body, which brings the wheels 5 inches nearer than in the ordinary vehicle, and yet also gives additional room in the width. The window runs along the roof on the inside, and draws down like a sash; and there is a sash door, which may be pushed down, and coils itself below the body of the vehicle. The ventilation is also improved. One style of Hansom has a top which slides down, and thus an open carriage is provided. The cost of vehicles is said to be considerably reduced by the new mode of construction.

For the Journal of the Franklin Institute.

On the Proportions of Cast Iron Steam or Water Pipes, with Faced Flange Joints. By Robert Briggs.

The proportions for cast iron pipes with faced flanges given by the following formulas and tables, have been reached after many years experience in their manufacture and use.

Those dimensions which are given by the first set of formulas (for 75 lbs. pressure) have been quite extensively adopted in the practice of engineers and machinists, the past eight or ten years. They give the minimum diameters to the flanges which will allow six sided nuts of proper diameters to be turned, and they give also such thickness to each flange, as has been found practically ample when the joint is faced all over, and either no packing or a very thin one over the whole joint surface is used. After the manufacture of many thousand of lengths, to these dimensions, no instance of failure to give tight joints or of breakage from unequal shrinking of the casting, or of breakage from want of strength is remembered. And the great excess of strength to withstand the internal pressure at which it is proposed to use them is made evident by the formulas. There has been found, however, a demand for flanged cast iron pipes to carry about 100 lbs. pressure, united with a requirement for flanges so large that the common square nuts (which have their inscribed diameters equal to twice that of the bolts on which they belong) can be readily turned on the back of the flanges, and also with a requirement for flanges so thick as to withstand the unfair strains occasioned by the use of packing rings made of yielding materials and placed within the diameters of the bolts as a substitute for surface packing.

It is of no avail to argue with those, who from false economy, purchase bolts and nuts by weight with little question as to quality, neither is it advisable to demonstrate the unworkmanlike character of the joints made by packing rings or the unmechanical procedure of making up lengths or getting small angles in this way. It is enough that flanges can be made sufficiently large and heavy to overcome these defects in construction and also sufficiently accurate to be used in the legitimate way. To meet these conditions the second set of formulas and tables have been made. It is not proposed at this time to enter into a discussion of the derivation or the character of the formulas. We will only say as regards the thickness, that on the smaller sizes, say below 12 inches diameter, the constant of thickness required for sound castings is very much in excess of that demanded to resist internal pressure and that the formulas establishing the number and size of bolts have been based on the assumption that for 75 lbs. pressure, four inch pipes require $5-\frac{9}{16}$ inch bolts, or for 100 lbs. pressure, the same size of pipes require $5-\frac{5}{8}$ inch bolts, and that for both 75 lbs. and 100 lbs. pressure, forty-eight inch pipes require $36-1\frac{1}{2}$ inch bolts. The results of this assumption as a whole system have been carefully investigated and found to give a value for the tensile strength of the wrought iron below the roots of the threads of the bolts, as compared with

the tensile strength of the cast iron demanded to sustain internal longitudinal pressure, in the ratios of $2\frac{1}{2}$ to $3\frac{1}{2}$ times, the lesser ratio being on the larger bolts where the danger of overstraining by the workman in screwing up the bolts is the least.

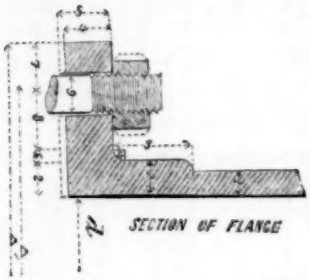
Formula for Thicknesses of Pipes, &c.

Let T = thickness of pipes in inches.
D = diameter of pipes "
d = diameter of bolt "
Δ = outside diameter of flange in ins.
Δ_1 = diameter of centre of bolt, "
K = tensile strength of cast iron.
c = co-efficient of safety above proof.
c_1 = co-efficient of proof above working pressure.
s = thickness necessary for sound castings for smallest pipe.
n = diameter of pipe which has such thickness that no addition for sound castings is required.
P = pressure per square inch in pounds.

The general equation of thickness then becomes,

$$T = \frac{P D c c_1}{2K} + s\left(1 - \frac{D}{n}\right)$$

Suppose $K = 18{,}000$ lbs per square inch,
$P = 75$ lbs.
$c = 3\frac{1}{4}$, $c_1 = 4$, $cc_1 = 15$.
$n = 48$ inches diameter.



which gives for seventy-five lbs. pressure and 15 times absolute strength, *without constant for sound castings*,

$$\therefore\ T = 0{\cdot}02604\ D + 0{\cdot}25$$

suppose as before except that

$P = 100$ lbs., $c = 3{\cdot}28$, $c_1 = 4$, $cc_1 = 13{\cdot}125$,

which gives for 100 lbs. pressure and 13·125 times absolute strength, *without constant for sound castings*,

$$\therefore\ T = 0{\cdot}0304\ D + 0{\cdot}292$$

Formula for the Flanges.

	75 lbs.	100 lbs.
1st. Thickness of pipe,	$T = 0{\cdot}026\ D + 0{\cdot}25''$	$= 0{\cdot}0304\ D + 0{\cdot}292''$
2d. Thickness of boss,	$= 0{\cdot}03\ D + 0{\cdot}31$	$= 0{\cdot}035\ D + 0{\cdot}44$
3d. Length of boss,	$= 0{\cdot}05\ D + 1{\cdot}10$	$= 0{\cdot}05\ D + 1{\cdot}10$
4th. Thickness of flange finished,	$= 0{\cdot}033\frac{1}{3}\ D + 0{\cdot}4$	$= 0{\cdot}04\ D + 0{\cdot}6$
5th. Thickness of flange in the rough,	$= 0{\cdot}036\frac{2}{3}\ D + 0{\cdot}45$	$= 0{\cdot}045\ D + 0{\cdot}86$
6th. Radius of hollow,	none given	$= 0{\cdot}008\ D + 0{\cdot}16$
7th. Centre of bolt to outside of flange,	$= 1{\cdot}1d + 0{\cdot}1$	$= 1{\cdot}25\,d + 0{\cdot}05$
8th. Centre of bolt to hollow at root of flange,	$= \left\{\begin{matrix} 1{\cdot}04d + 0{\cdot}2 \\ \text{to root itself} \end{matrix}\right\}$	$= 1{\cdot}25\,d + 0{\cdot}1$
9th. diameter of holes in flange,	$= 1{\cdot}03\,d + 0{\cdot}03$	$= 103d + 0{\cdot}03$
Δ = outside diameter of flange,	$= 1{\cdot}06\ D + 4{\cdot}28d + 1{\cdot}22$	$= 1{\cdot}086D + 5d + 1{\cdot}50$
Δ_1 = diameter of centre of holes,	$= 1{\cdot}06\ D + 2{\cdot}08d + 1{\cdot}02$	$= 1{\cdot}086D + 2{\cdot}5d + 1{\cdot}40$
N = number of bolts,	$= 0{\cdot}7046\ D + 2{\cdot}182$	
d = diameter of bolts,	$= 1{\cdot}182\sqrt{\frac{0{\cdot}01785\Delta_1{}^2 + 0{\cdot}2052}{N}} + 0{\cdot}0492$ *	

* The value of Δ_1 under the radical in this formula, is taken at an average computed one of $\Delta_1 = 1{\cdot}1043\ D + 2{\cdot}0127$

In the tables following the exact figures obtained for Δ, Δ_1, N, and *d*, by the formulas are not given but instead, the aliquot figures in inches or sixteenths nearest to fractional ones derived by computation.

There is besides the dimensions derived from the formulas, two columns giving the convenient lengths for each piece and the calculated weight of each length with the flanges in the rough.

Table of dimensions for Flanged Joint Cast Iron Pipes, intended to carry 75 lbs. per square inch working pressure.

Internal Diameter.	1st. Thickness of body.	2d. Thickness of boss.	3d. Length of boss.	4th. Thickness of flange finished.	5th. Thickness of flange in the rough.	6th. Radius of hollow.	9th. diameter of bolt hole.	Δ = outside diameter of flange.	Δ_1 = diameter of centres of bolts.	N = number of bolts.	*d* = diameter of bolts.	Length convenient to cast each piece.	Weight of each piece with flanges in the rough.
in.										No.	in.	ft.	lbs.
3	·328	·40	1·25	·50	·56		·55	6½	5¼	4	½	8	94
3½	·341	·415	1·28	·511	·571		·61	7¼	5 9/16	4	9/16	8	113
4	·354	·43	1·30	·53	.593		·61	8	6 7/16	5*	9/16	8	134
5	·380	·46	1·35	·56	·626		·61	9	7½	6	9/16	8	176
6	·406	·49	1·40	·60	·67		·68	10¼	8 11/16	6	9/16	9	250
8	·458	.55	1·50	·66	·736		·68	12½	10 13/16	8	9/16	9	360
10	.510	·61	1·60	·73	·81		·81	15	13 2/16	10	9/16	9	514
12	·563	·67	1·70	·80	·89		·93	17¾	15 9/16	10	9/16	9	685
16	·667	·79	1·90	·93	1·013		·93	22	19 5/16	14	9/16	9	1110

Table of dimensions for Flanged Joint Cast Iron Pipes intended to carry 100 lbs. per square inch working pressure.

in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	No.	in.	ft.	lbs.
3	.3832	·545	1·25	·72	·8	·184	·61	7½	6	4	9/16	8	118½
3½	·3984	·563	1·28	·74	·82	·188	·61	8	6½	5†	9/16	8	139
4	·4136	·580	1·30	·76	·84	·192	·68	9	7¼	5‡	9/16	8	166
5	·4440	·615	1·35	·80	·89	·200	·68	10	8¾	6	9/16	8	217
6	·4744	·650	1·40	·84	·93	·208	·68	11	9¾	6	9/16	9	303
8	·5352	·720	1·50	·92	1·02	·224	·68	13½	11¾	8	9/16	9	451
10	·5960	·790	1·60	1·00	1·11	·240	·81	16	14	10	9/16	9	624
12	·6568	·860	1·70	1·08	1·20	·256	·93	19	16¾	10	9/16	9	832
16	·7784	1·000	1·90	1·24	1·38	·288	·93	23½	21	14	9/16	9	1309

* 4 — ⅝ bolts could be used for this joint in place of the tabular number and size, but the joint will be better if the number and dimensions given are followed.

† ‡ The 3½ inch pipe flanges can have 4 — ⅝ bolts and 4 inch can have 4 — ¾ bolts, but the joint will not be so well made as with the tabular numbers and diameters.

Puddling by Machinery.

From the London Builder, No. 1150.

Amongst the papers set down to be read at the annual meeting of the Institution of Mechanical Engineers in Birmingham, on the 26th ult., was one upon "machine puddling," by Mr. Menelaus. The

author of the paper was accompanied by the manager of the Dowlais Company, who have the use of the patent. Mr. Menelaus had in the room a bloom of iron in the condition in which it left the furnace, and which weighed 5 cwt. As it lay upon the floor it looked like a hugh iron egg, and near to it were specimens of the same iron in a finished state. There were also diagrams, not only of the furnace in question, but also of the various descriptions of furnaces which contemplated the stirrings of the molten iron in the ordinary puddling furnace with a "rabble" or puddler's tool moved by machinery, so as to imitate manual labor. Mr. Menelaus said that he had thoroughly satisfied himself of the practical value of the invention; and the Dowlais Company were then engaged in laying down works, in which eight of those rotating furnaces could be kept in operation in the production of an unexceptionable quality of finished iron. The quality of the bloom and of the iron in the finished state, which had been rolled from other blooms made in the furnace, was pronounced excellent. Every such furnace as that now used at the Dowlais Works can easily produce 60 tons of iron a week. It is said that by the use of the rotary furnace the expense of production will be diminished, as compared with the cost of iron made by hand labor, at the same time that the quality is improved.

Thin Rolled Iron.

From the London Athenæum Jan., 1865.

A great feat has been lately performed. A sheet has been rolled from common iron at Messrs. Williams's iron mills, at West Bromwich, which is only the 1015th part on an inch in thickness. Another sheet, the 1400th part of an inch thick, has been produced by Messrs. Nevill, of Llanelly.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, March 16th, 1865.

The meeting was called to order with the President, Wm. Sellers, in the chair.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were read and the names of the chairmen of the various standing committees were announced as follows:—

Committees.	*Chairmen.*
Library,	Pliny E. Chase.
Cabinet of Models,	John L. Perkins.
Cabinet of Minerals,	Coleman Sellers.
Cabinet of Arts and Manufactures,	John H. Cooper.
Meteorology,	James A. Kirkpatrick.
Exhibitions,	Bloomfield H. Moore.
Meetings,	Fairman Rogers.

The following donations to the Library were also reported, from the Royal Astronomical Society, the Royal Geographical Society, the Statistical Society, the Society of Arts, and the Institute of Actuaries, London; the Canadian Institute, Toronto, Canada; Hon. Wm. D. Kelley, U.S.Congress; Frederick Emmerick, Esq., Washington D.C.; Joel Giles, Esq., Dr. Thomas S. Kirkbride, and H. Morton, Philadelphia.

The Committee on the adoption of a standard for Weights, Measures, and Coinage of the United States reported progress.

The Committee on steam expansion reported that the time as yet devoted to the subject had been occupied in the arrangement and construction of apparatus and in the determination of certain constants which must play an important part in the calculations connected with the actual experiments.

The Committee on Screw Threads and Nuts reported that they had received letters from F. V. Rodman, Major of Ordnance, M. C. Meigs, Quarter-Master General, and from J. F. Holloway, Cleveland, Ohio, in general terms endorsing and approving of the report of the Committee.

On motion of Coleman Sellers, Esq., the report of said Committee after being read was finally adopted.

The Committee to draft a petition to Councils with reference to the appointment of an inspector for steam boilers, reported the draft of said petition, which being read, it was moved by Prof. Frazer, that the officers of the Institute be instructed to sign, seal, and cause to be presented, the aforesaid petition. This motion was carried.

Prof. Fairman Rogers then described the apparatus which had been prepared for the experiments on steam expansion, in effect, as follows:

Mr. Fairman Rogers.—If there is nothing else to occupy the attention of the meeting, I think that it would be interesting to the members to have some description of the essential portions of the apparatus used in the experiments on the expansion of steam now being made in New York.

I should the more like to describe it as we are anxious to have the opinions of persons interested, as to the method of experimenting which is employed.

It is known to the members generally, that the commission is appointed from the Franklin Institute, the National Academy of Sciences, and the Navy Department, the appointments being made by the authority of the Navy Department.

The object of the experiments is the determination of the relative economy of different degrees of expansion.

It will be remembered that Mr. Isherwood, Chief Engineer U. S. Navy, has for some time held the opinion, that *all practical questions being considered*, there is little or no advantage in the use of steam expansively in steam vessels. These views are the results of experiments made by him and under his direction, and are quite at variance with those held by engineers generally, and the difficulty has hitherto been

that all such experiments were made with engines especially intended for some particular degree of expansion, and therefore not adapted to experiments for the comparison of the results of varying degrees.

The Navy Department desired therefore to have the experiment made with an engine built expressly for the purpose.

The apparatus was built by Mr. Allen of the Novelty Works, who, with Mr. Isherwood, at that time composed the commission. After the apparatus was set up, the joint commission was appointed.

The apparatus consists of a large engine which has a number of cylinders of different diameters and the same stroke (20 inches); the cubic capacities of the cylinders vary with their varying diameters and the valve gear is so arranged that they each receive the same amount of steam before cutting off, in other words, they each use the same quantity of steam at each stroke.

The engine is a vertical engine with a fly-wheel and accurately balanced, and the cylinders are changed by unbolting them from the bed plate which has the proper arrangements to receive the different sizes.

After the form of engine was decided upon, the work to be done or the kind of resistance to be provided was discussed.

A centrifugal pump raising a certain quantity of water in a given time was proposed and abandoned out of deference to the opinions of many engineers who were consulted. The friction dynamometer appeared still more objectionable in experiments that were to be carried on continuously for many hours at a time, and finally the plan of fans rotating in air was adopted.

Seventeen fans on a shaft, which is a prolongation of the engine-shaft were provided, each fan rotating in an air-tight chamber.

The fans are eleven feet in diameter, have eight arms, and vanes which are adjustable to the arms, and with the chambers are as much alike as it was possible to make them. The fan-shaft is cut between the fans so that by means of sleeve couplings any number may be run together.

If the full stroke cylinder with a certain pressure and a certain number of revolutions would run ten fans a certain number of revolutions, the work done by any other cylinder of the same pressure will be represented by the number of fans run by it.

Since, however, fractional fans or fans of reduced diameter might be necessary to furnish the exact amount of resistance, it is desirable to have some way of measuring the resistance thus produced, the more so, as it was predicted that the changes of barometric pressure and of temperature would have a very serious effect on the regularity of the running of the fans.

Mr. Allen therefore proposed a dynamometer which has been put in operation and to which I wish particularly to call your attention.

The shaft being cut between the engine and the first fan, a grooved pulley is keyed upon the engine shaft and one exactly similar upon the fan shaft. An endless rope is laid over these two pulleys in such a way that the bight of the rope hangs down before and behind. In these bights are hung two grooved pulleys of a diameter equal to the

distance of the large pulleys apart, and to these smaller pulleys equal weights, so that the rope is held tightly in the grooves of the large pulleys. The engine pulley being turned by the engine, sufficient extra weight is added to the hanging pulley on the driving side of the rope to equal the strain on the rope which represents the resistance of the fans, when the whole system will be in equilibrium and the amount of power required to drive the fans will be measured by the tension of the rope, and consequently by half the extra weight which has been added.

If the resistance of the fans increases by any means, the weight rises; if the resistance diminishes, the weight falls, and a spring balance is fastened to the weight and to the floor to take up these irregularities.

A rod attached to the weight and carrying a pencil moving over the surface of a cylinder running from the shaft, serves to register the power required to run the fans.

By this apparatus the friction of the fan-shaft can be measured and any change in the resistance from varying density of the air is immediately indicated.

The experiments so far led to the belief that the changes from this cause will not be troublesome in amount.

It is found that the pencil rises and falls with each stroke of the engine, showing irregularities at different parts of the stroke, although the engine seemed to be well balanced.

Another wheel will be added to the train which runs the paper so that the curve will be more developed and the action of the engine may be more carefully studied.

The same result can be obtained by using four bevel wheels, but there might be some uncertainty as to the equal wear of these wheels.

At first it was supposed that the fans should run faster than the engine, and they were geared four to one, but the wheels were somewhat noisy, and showed signs of irregular wear which, it was feared, might affect the results. The wheels were therefore removed, and the fans run directly from the engine-shaft, their diameter being increased. Of course by taking off the dynamometer rope and coupling the shaft between the large pulleys, the fans can be run without the dynamometer.

Every precaution has been taken in regard to the oiling. Where there are so many journals this is of great importance, and it has been found best to give a very abundant supply of oil and to use the oil only for a short time as it seems to be injured by its exposure to the air.

There are many matters of detail, the consideration of which would detain us too long, but I will mention the arrangement used to keep the steam at a constant pressure in the cylinder. It was at first done by a man at the throttle, but that was not altogether satisfactory, and an arrangement devised by one of the assistant engineers was adopted.

The valve is opened or closed by a screw spindle which has a rather fine thread; on this spindle are two ratchet wheels with the teeth

turned in opposite directions; over these wheels are two palls or clicks which receive a constant reciprocating motion from the engine.

The mercury column representing the pressure, rises and falls in a glass tube in which pointed wires are arranged in such a manner that when the mercury rises above the desired point, a galvanic circuit is closed, an electro-magnet is formed, and one of the palls is drawn down into contact with one of the ratchet wheels which it works, thus closing the throttle.

Upon the mercury receding the pall is disengaged and the valve remains steady.

If the mercury falls too low and the circuit is broken, a spring brings the other pall into contact with its wheel and the throttle is opened until the proper pressure is restored. This regulator gives great satisfaction, the only difficulty being that the mercury (or some impurities in it) sometimes adheres in threads to the platinum points.

Prof. Vanderweyde.—What results have been arrived at as to the economy of expansion?

Mr. Rogers.—Up to this time the experiments have all been directed towards perfecting the apparatus, determining the friction, &c. It is not yet considered to be in a state to permit the regular experiments being undertaken, but it is nearly perfected.

Mr. Coleman Sellers.—I would ask if the irregularities referred to in the register of the dynamometer might not be due to the elasticity of the cord which passes over the pulleys. May this not stretch and contract at different parts of its length?

Mr. Rogers.—It is possible; but the variations appear to coincide with the revolutions of the engine. The more expanded curve will show this more clearly.

The cord is made of raw-hide twisted and wormed with spun yarn, soaked in oil and well rosined. Some trouble was occasioned by the oil coming out of the rope for ten days or more after it was put up and by the stretching of the rope.

Mr. Shaw.—I made and used, some ten years ago, a dynamometer somewhat upon the same principle, which worked remarkably well.

It consisted of a pulley loose upon the shaft which was to be worked. The belt from the engine ran on the face of the pulley and a cord from one arm of the pulley drew the shaft round by a radial arm fixed to the shaft. To enable me to measure the tension of this cord it was passed through a pulley at the end of the radial arm and down to a sliding sleeve on the shaft which was drawn outwards by a weight or a spring. This sliding sleeve may in fact be done away with, and a swivel in the cord used. This is not effected by the stretching of the cord.

Mr. Rogers.—That form is new to me, although I have seen a description of something nearly like it.

The President, Mr. Wm. Sellers.—I think that one of the difficulties with the dynamometer described by Prof. Rogers, would be the varying friction of the shafts owing to the varying load on the cord, for different amounts of work to be measured.

As you increase the work you must increase the excess of weight which measures it and you thereby produce a change in the friction which it will be difficult to calculate.

Mr. Rogers.—The load which forces the cord into the grooves of the pulleys is a constant one, and it is only the excess of weight on the driving side which changes, and the friction on the shaft is part of the resistance which is measured by the dynamometer.

Mr. Wm. Sellers.—It would be upon the engine-shaft also.

Mr. Rogers.—Yes, that is one of the difficulties, and we propose to determine these resistances in the engine by special experiment; but I do not see how any dynamometer could be arranged which would not be liable to the same objection.

Mr. Wm. Sellers.—The friction caused by the pressure necessary to cause the cord to take hold in the grooves, is greater than that which would occur with gearing.

Mr. Rogers.—There is no doubt that the friction with gearing is much less than with the pulley or with any kind of cord, but it is doubtful whether the gearing would keep in good condition or whether it would not be liable to some changes which we could not readily detect.

Prof. Frazer.—The irregular working of the first gearing shows that there must have been some resistance of which you are not aware.

Mr. Rogers.—When you have command of the size of the gearing, and where the four wheels could be exactly of the same size, I do not think that the irregularity of wear could be a serious matter.

Prof. Frazer.—You do not mean that the pressure on the journals would vary during the experiment; only that it would be greater when the dynamometer was on, than when it was off.

Mr. Rogers.—During the series it would vary with increased power in the engine; increased weight would be required to produce tension enough in the cord to transmit the power.

Mr. Wm. Sellers.—The difficulty would be to compare one experiment with the other.

Mr. Rogers.—It is proposed to determine these differences as nearly as possible and it can hardly be difficult to measure the friction with the data which we have.

President.—If there are no other remarks, the report from the Secretary would be in order.

Mr. Thomas Shaw.—I would like to make some observations upon engine counters; as they are at present, they are liable to get out of order; I have an arrangement operated by a crank which is not liable to that objection. I propose to connect directly with the crank; I connect with a vibrating rod or elastic pitman; the difficulty in the employment of the crank is the dead point. I propose to get over these points by means of a spring fixed at right angles to the line of motion. This rod might be constructed so as to compensate for the action of heat and cold; the slightest alteration of the rods alters the engine counter and prevents it from operating.

President.—The Secretary's report is now in order.

SECRETARY'S REPORT.

The Secretary then read his report on new discoveries and inventions, as follows:

Mechanics.—Under this head we have first to notice a paper read before the Mechanical Engineers' Society of London, in which is given a very full description of several *traversing cranes* recently erected in the Locomotive Works of the London & N. W. R. R. at Crewe. These cranes, of which seven are now in use, have been working in a satisfactory manner, some of them for as long as three years. Motion is communicated to them by a light cotton cord running the whole length of the shop traversed by the crane, and driven at the rate of sixty miles per hour, its force being taken up as required at the different points by friction disks and pulleys. It is also stated that the cords employed do not wear out as rapidly as might be expected, but last on the average as much as 10 months each. They pass, in turning, over very large pulleys and are elsewhere supported in smoothly polished shoes of iron or glass.

We should remark with regard to these cranes, that their usefulness, though unquestionable, is mainly confined to such business as that of the locomotive shop, as in other establishments the necessity of a *successive* use of the apparatus by different parties of workmen, would entail an injurious loss of time.

Much has also been written in various English journals on the subject of a pneumatic machine for weaving, whose chief points of originality consists in the movement of the shuttle, which is blown back and forth by a blast of air, thus, as it is claimed, obviating the friction, heating and consequent injurious effluvia of charred oil, as well as the danger of greasing the fabric.

A gas engine, *i. e.*, one in which motion is produced by explosion of burning gas mixed with air, claims much attention from the French and English journals. This apparatus is patented by a M. Lenoir, and if as efficient as it is represented to be, will possess value as an easily arranged generator of moderate force, not bulky and capable of use and discontinuance without loss of time or fuel in preparation. Though the steam engine at present fears no rival as an economical force developer on the grand scale, there are many objects to which some small but *convenient* prime motor might be very advantageously applied, even though in economical utilization of the force implied, in its fuel it were greatly inferior to the above.

We have also to notice an improved form of chair for joining rails patented by R. H. Lamborn, of this city. This consists of a rectangular trough or gutter of wrought iron, in which the ends of the rails to be united are set, being kept in place by a yoke or staple of iron, passed through the neck of each rail near its end, and fastened by a split key, driven through the ends of the yokes below the trough. The apparatus consists of but five parts, the trough, two yokes and two keys, all of the simplest construction. This chair has been tried on the Penna. Cent. R. R. near Altoona, with such success that ten miles of track are being laid with it by this company, and very strong endorsement has been given to the plan by eminent engineers.

There has also been presented an improved balanced rotating steam valve by Arthur Irvine, of Philadelphia. This consists of a three port rotating cylindrical valve, balanced by the exposure of a part of the cylinder through a properly arranged packing-box at the side opposite to the exhaust port. A hood may also be attached over this opening in low pressure engines and connected with the condenser.

We have also to notice an oiler or cast iron oil can for lubricating machinery in motion, by Richard Dudgeon, of New York, the inventor of the hydraulic jack. The body of this can is cast in one piece, and has a plunger (inserted through a proper packing), which, being forced in by a motion of the thumb, drives out a jet of oil from the nozzle of the can.

Physics.—Light. A substitute for the yellow glass used by photographers to intercept actinic rays has been suggested by W. Sidney Gibbons of Melbourn. This is a mixture of gelatine and bichromate of potash spread as a varnish over thin cotton cloth or similar material. The same material mixed with lampblack is also said to form an excellent paint for a black-board, as it becomes after exposure to light very tough, and is unaffected by washing.

A very interesting memoir by Dr. Tyndall, on the invisible heat rays accompanying light has been read before.

In this paper are described experiments made with a spectroscope entirely constructed lenses, prisms, &c., of rock salt, and with very dark solutions of iodine in bisulphide of carbon, by which the light rays may be entirely arrested while those of heat pass freely. By these means it was possible in a perfectly dark room, to focul upon a certain point the rays from an electric lamp so that intense heat was developed in this spot without, however, the least appearance of light. The experimenter also daringly placed his eye in this heat focus, and though the lid was scorched when unprotected, yet when this was guarded against, no sensation was produced by the passage of the heat rays into the pupil, owing, no doubt, to the fact that they were absorbed by the aqueous humors of the eye lenses.

A megascope or magic lantern for opaque pictures illuminated by the lime-light has been patented by a Mr. Chadburn, optician, of Liverpool. This is, however, a very old instrument revived, rather than a new invention, and of interest only because our present great facilities for producing intense light enable us to use such apparatus with ease and good effect.

We have also another modification of the same apparatus in the Photographiscope Catoptric Lantern patented by Geo. Sibbald, of Phila. The light is here obtained from two coal oil lamps, and from its ease of management may be of great value to artists and manufacturers of decorative articles, enabling the first to produce readily, an enlarged and accurate outline from a small photograph or the like ; and the last to see the effect of any design, with all its colors, &c., enlarged to any desired extent. (This instrument was then exhibited in operation.)

Electricity. An application of secondary or induced currents to telegraphic purposes is found in a patent granted to I. B. Thompson,

London. The plan of apparatus here proposed seems simple and well arranged and the idea embodied a very good one. Intense batteries, implying in practice the use of nitric acid are troublesome and expensive to maintain; while intense currents must yet be had to work long lines. Any means, therefore, by which a low intensity battery almost self-regulating like that of Smee, can be made to furnish the requisite intense force without increase to the number, but only to the size of its elements, is a great and valuable acquisition.

We see, also, a proposed plan for pointing pins and needles, without such injury to the health of the workmen as attends the present grinding process, invented by a M. Cauderay, of Paris. The wires to be sharpened are attached to the positive pole of a battery, and then plunged in acidulated water, connected by a plate of metal, with the negative pole. They then quickly become pointed, even with a feeble current, as is asserted.

Chemistry.—The so-called passive state of metals has been proved by Dr. Heldt, to result from the formation of an insoluble film differing in different cases, but always protecting the metal from the attack of the acid or other solvent.—*Les Mondes*, vol. vi., page 413.

Richt and Richter have obtained enough of their new element, indium, to determine its physical properties. It is a white metal, soft, ductile, not easily tarnished, melts at about the same point as lead, gives a blue color to flame when combined with chlorine or sulphur. Its specific gravity is 7·277, and equivalent 37·07, that of hydrogen being 1.

Cæsium has been found by M. Pisani to form 34 per cent. of the mineral Pollux, in Elba.

Tellurium has been found in an ore of bismuth on the mountain Illampu in Bolivia.

Iodine has been found in Chili as an iodide of lead associated with PbO and PbCl.

St. Caire Deville has published some very curious experiments, from which it would appear that at a very high temperature the firmest chemical compounds were decomposed.—*Comptes Rendus*, vol. lix, page 873.

An ingenious process for ornamenting glass is embodied in a paper read by Mr. Kuhlman, before the Academy of Sciences.

Glass plates are coated with solutions of sulphate of zinc, or of magnesia thickened with gum water. This material soon crystallizes in very beautiful arborescent figures which may be then etched into the glass by the use of hydrofluoric acid, and afterwards colored by the fusion of substances which may have been mixed as fine powders with the gum-water, &c., first mentioned, or the glass may be silvered, which gives a very pretty effect.

The theory of steel has been the subject of fresh discussion and the "carbon hypothesis" ably supported by William Baker and Graham Stuart, from experiments made by them with many specimens of the best kinds of iron; also by M. Margueritte before the Paris Academy of Sciences.

After the conclusion of the report, the meeting was, on motion, adjourned.

HENRY MORTON, *Secretary.*